PHYSIOTHERAPY TECHNIC

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A MANUAL OF APPLIED PHYSICS

By

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WITH EIGHTY-FIVE ILLUSTRATIONS

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DEDICATION

This work on physiotherapy technic is dedicated to the section of the medical profession that will make the most use of it—the Therapeutic Peptimists. A peptimist is an optimist who envisions much better things than are even now possible and has the determination, courage, ability and energy to go out and make his vision come true. He is the antithesis of the therapeutic nihilist.

That the results secured by properly applied physiotherapy in the late war reconstruction hospitals resulted in the conversion of thousands of physicians from a state of therapeutic pessimism to one of optimism cannot be denied and that a renaissance in therapy is now in full swing as a result is evident to any physician who attends the various medical meetings over the country. No longer is it true that the peptimist is, of necessity, a lone wolf. His popularity is increasing by leaps and bounds and his numbers, naturally, are growing. May this very desirable state of affairs continue. To him is this work dedicated.

PREFACE

The main body of the medical profession is conservative and has many strong and valid reasons for so being. The conservative is a compromise between the progressive who demands progress, even at the risk of getting off the road at times and of having to retrace his steps, and the ultraconservative who wishes to stop progress and dig in because he is satisfied with present conditions and does not care to make any change whatever. The true conservative is not satisfied with no progress but refuses to advance until the ground has been scouted and its advantages and disadvantages are known and the best route of progress laid out. In charting this route he can, and most often does, take advantage of information gained by the progressive at risks that he himself would have advised against, but which having been gained he would be foolish to ignore. Thus the true conservative is the man who makes the fastest progress. If the main body of the profession were progressives the profession would lose prestige by often being discredited. If the main body were ultraconservatives all progress would stop.

I realize that a conservative statement of fact upon the results secured by the use of new technics is going to be branded as rank radicalism by the ultraconservative because to an ultraconservative a real conservative appears to be a radical. This is a risk that must be taken. Practically every step in every technic given in this book is based upon research both in the laboratory and clinic and the results have been checked both by myself and many others who, probably, could not be accused of being prejudiced in favor of the methods. Not a single technic which failed to stand such checking has been included.

I wish to thank the editors of the *American Journal of Roentgenology* and the *American Journal of Electrotherapeutics and Radiology* for their courtesy in allowing me to reproduce the articles included in this book which first appeared in their re-

spective journals; my many friends who have helped me by their advice and unselfish labor in getting the manuscript into type and more presentable form; John F. Stokes for the drawings in the static and high frequency sections, and Mr. Buttolph, of the Cooper Hewitt Co., of Hoboken, N. J., for the diagram of the starting and operating voltage and amperage curves on ultraviolet generators and for the spectrum photographs.

New York City, C. M. Sampson.
April, 1923.

CONTENTS

ILLUSTRATIONS

PHYSIOTHERAPY TECHNIC

INTRODUCTION

These technics have been put into book form as the result of the intense interest their demonstration in the service clinics has aroused. They are not put forward with the word that they are the only ones with which one can obtain results or that they are the very final word in physiotherapy. Neither do I think that they are so perfect that they cannot be improved upon, for I, myself, am constantly refining them, adding to them or discarding a proved good technic when I work out a better one, etc. Each procedure is advanced simply as one that I have found best in all the circumstances, and circumstances in other clinics may make changes or substitutions desirable and beneficial. My aim is not to advise the discarding of all technic that differs from my own *(unless it differs basically)* but rather to furnish the doctor or staffs of institutions just starting in physiotherapy with a proved good method to start with and thus save many of the difficulties they would otherwise have in working out a technic for themselves and, incidentally, to give those already having their procedures worked out an opportunity to compare methods and possibly to improve both to our mutual profit and the benefit of our patients.

After all is said and done the personal equation is bound to enter into the building of a technic. As well expect all baseball pitchers to accept a standard style of delivery, confine themselves to it exclusively, and continue to remain effective as to ask all physiotherapists to adhere, *rigidly*, to certain set procedures and then look for uniformly good results. The advice of a wise old baseball pitcher coaching a coming youngster is just as valuable in showing the new man faults to be avoided as it is in showing him the proper methods of doing the things advised. The youngster, after sufficient practice and experience,

may develop into a better pitcher than his coach, but if he does his style of delivery will differ in many ways from that of his preceptor. And this is as it should be. A close analysis of his style of delivery, however, will show that he, in common with all other star pitchers, has observed all the fundamental or *basic laws* that apply. Disregard of even a *single one* of these basic laws would spell failure. How much more true is this when instead of dealing with simple physics we are dealing with applied physics and have to calculate, closely, the reactions that will follow the application of these physical remedies to the human organism with its complex reactions and reflexes.

It is my intention to make this book different from any other now available on therapy. It is not being written to boost any particular make of appliances and if I show a cut of one manufacturer's apparatus simply as such I cannot, in fairness, leave out others of the same type but different makes. To show them all would make the work resemble a catalogue and pad it to large dimensions. Therefore, I shall only show cuts of apparatus where necessary to illustrate the actual giving of treatments or to make plain a point. As this is not a historical work I shall not attempt to trace the progress down through the years by showing a lot of obsolete apparatus that, *even if it could be duplicated,* would not be practical. I reserve the right to express my opinion as to the best make of a given kind of appliance and further reserve the right to change my mind later if some one else puts out a better outfit or if some present maker so improves his outfit that it surpasses the one named.

The technics given in the following pages are the ones that met every test in the great flood of cases that passed through our various clinics in the reconstruction hospitals following the late war. Almost all of them were worked out by myself either during the reconstruction period or some years before and improved during this period. If I quote a technic originated by another man I shall give him credit even if I have modified it greatly. As nearly as may be I shall give the reason for each step as we go along. We do not intend to start down the alphabet of diseases and injuries and prescribe for each one. No two cases of the same name are exactly alike and the same case

varies from day to day. The indication of today may be the contraindication tomorrow. My task is to show *how* to initiate, accelerate, retard or neutralize various reactions in the human body. The desirability of any given reaction being produced or its degree will be a matter for individual judgment as any attempt to cover the whole ground would run the work into the voluminous proportions of a practice of physiotherapy and defeat the object—to give a short practical manual on technic. Neither am I going to load the text with case histories. A few to illustrate, here and there, may become necessary but in the main I am going to give my conclusions based upon results in a large number of cases and treatments.

I had almost unlimited opportunity to test out modalities and technics. For instance, in one of our hospitals from first to last were over seventeen hundred peripheral nerve injuries. Over six hundred were there at one time. And so it went. Where in private practice we would have seen one or a few cases of a given kind, we now had them by scores and hundreds. We were called upon to treat cases that looked absolutely hopeless; cases that had several diseases or disabilities any one of which would give a gloomy prognosis, but much of our very best work was done upon some of these human derelicts. The physiotherapy service became in very truth the human salvage service. Surgeons learned that cases that had become inoperable might, in some instances at least, be brought back to the realms of surgical possibilities. They learned that physiotherapy might, and often did, put an operated case that they had already consigned to the failure percentage column back into the successes. Internists learned that many and various physical agencies could be used as adjuvants to their treatment and, in some cases at least, could produce with more certainty and control and less undesirable after effects, reactions they desired than could be done with medication. More than one genitourinary man, startled at results in some case he referred to us and later tested with more of the same or other kinds, asked for and received a course of training in our clinic. The skin specialist leaned upon our clinic heavily and many cases of inoperable tonsils, hay fever, conjunctivitis, optic neuritis, etc., were gladly referred

to us for treatment after the eye, ear, nose and throat section "discovered" us.

For a physiotherapy clinic to grow in less than a year from its start into one comprising one hundred and ten trained operators giving an average of twenty-three hundred physical treatments a day (and prevented from exceeding this only by lack of room and the army policy of early abandonment of all temporary

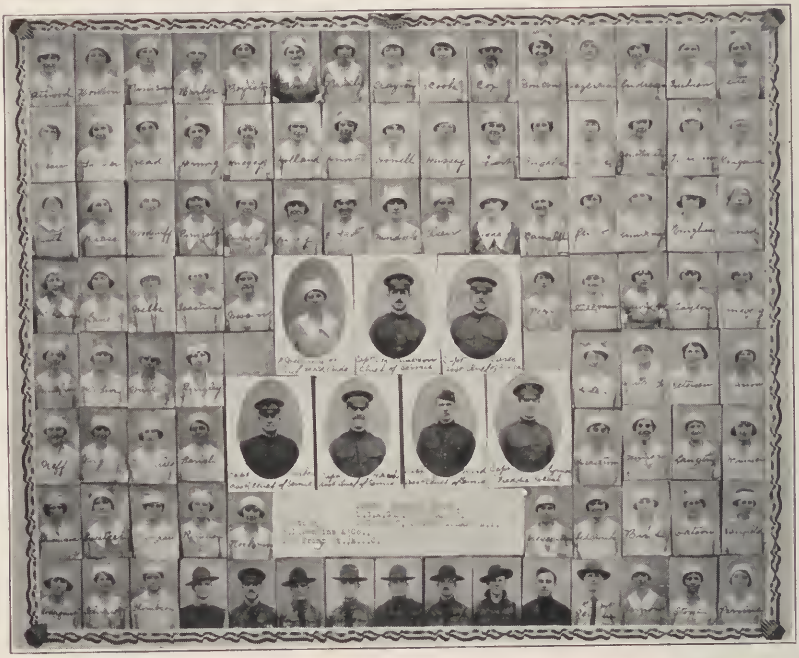

Fig. 1.—Commissioned Officer, Reconstruction Aide and Enlisted Personnel of U. S. Army General Hospital No. 41, Fox Hills, N. Y. Physiotherapy Service. This staff made the record of giving twenty-three hundred physical treatments a day. All of the aides were highly trained in massage, manipulation, exercises, etc., and most were trained in one or more departments where electrical treatments were given. Many were trained in every branch in the service and acted as instructors in the classes that were constantly being conducted both for the training of our own operators and for the training of officers and aides sent in for instruction in physiotherapy.

building hospitals forcing the beginning evacuation of the hospital) tells quite a story, and this is the story of only one such clinic. From an attitude of indifference or frank hostility on the part of a medical staff to one where we had to post waiting lists, put out S.R.O. sign and defend our action before the com-

manding officer was also our experience in at least two hospitals. From an attitude that officially forbade us to use diathermia on a certain class of cases to a time, shortly after, when we were compelled to apologize to that same official for our inability to comply with orders from surgeons in his own service to "give every patient from our wards taking physiotherapy in your department diathermia" was the result of treating these cases with *proper* appliances and technic. When we returned the requests with the endorsement "Why is the request made?" the answer came back, "These cases receiving diathermia are improving so much faster and are so much less trouble to the nurses and surgeons than those that are not getting it that it is only fair that all have it." Needless to say that these requests were forwarded together with a small one from us for more apparatus, room and personnel—all of which we received.

Right here I cannot refrain from stating that the magnificent showing made by physiotherapy would have been in no way possible if it had not been for the wholehearted and unreserved cooperation of Surgeon General Ireland of the United States Army (who practically risked his official position to insure that we should have a clinical instead of a political trial), Colonel Billings, Chief of Reconstruction Section, Major F. B. Granger, Chief of Physiotherapy Section in the Surgeon General's office, the Commanding Officer of the hospitals and also of Surgeon General Cumming of the United States Public Health Service, Dr. Lavender, Chief of the Hospital Section, Drs. Maddox and Carr of the Reconstruction Section and the Medical Officer in Charge of the Public Health hospitals. Their help we could always bank upon. I have not served in the Navy but know that Surgeon General Stitt has taken the same stand in the Navy hospitals and that several very fine physiotherapy clinics have been established in some of their main hospitals. The members of the hospital staffs adopted various attitudes but mostly one of being from Missouri. It should be said, though, that most of them were perfectly willing to be shown and that the very great majority after having been shown gave us every courtesy and their cooperation. Some *few* doubted physiotherapy, later

doubted their eyesight after seeing and now they are doubting the oculist.

I have every sympathy and respect for the physician who will not believe until he has been shown. How shall I express my opinion of the pseudoscientist, medical or otherwise, who takes upon himself the terrible responsibility of condemning offhand as either inefficient or dangerous a method of treatment that he has never used or seen used rightly and of which, when he is pinned right down to cases, he admits that he knows absolutely nothing? They are obstructionists, pure and simple, and so long as their tactics are applauded or *even tolerated* the medical profession is going to make very slow progress and the irregulars are going to continue to gain in numbers and legal standing. No intelligent physician who has ever used *physical* remedies according to their indications and with the proper appliances and technic is ever going to be satisfied to go along without them being added to the rest of his remedies for *he* will recognize their indispensability. Neither is he going to feel any competition from the irregulars. When a *medical man* knows and can use physical remedies correctly and support them with indicated medical treatment he has so much edge upon a nonmedical man, who tries (oftentimes with a very crude "system") to stretch the indications for one or two procedures—and who is restricted to such procedures—to cover *everything* that comes to him, that he should laugh at such competition.

I am not going to argue the case of physiotherapy all through the volume. The case has been carried to and through the supreme court of therapy and the verdict of the court (the thousands of the very best men in the profession—regular and reserve—gathered into the service hospitals) after an extremely critical review of all the evidence is that no hospital can claim to be modern that does not have and use physiotherapy. I may take up the cudgel now and again to fight attempts to foist off onto the profession a technic I *know* to be faulty and when I do, I do not care who or what is behind such technic. I shall reverse myself at any time when and if *proved* wrong, but I have long since passed the stage when awe or sentiment would

influence me or where I would accept hyperthermal atmosphere as *proof.*

The reconstruction experience has been an experience that few of us would willingly have missed, as long as the work had to be done, but which all of us hope, please God! never to have to go through with again. One of the outstanding therapeutic lessons learned was that physiotherapy has a great deal more than made good and is destined to be the salvation of therapy. Others are: that it is an indispensable part of medical and surgical practice; that it is not a separate cult or ism but can do its *best* work only in institutions such as general hospitals or in group practice where expert advice from all angles can and will always be given; that it is a very large and special field and requires special training and experience and much more time than can be given to it by men following other specialties at the same time and, further, that where it has failed in the past there have been ample reasons. I have set my task to point out a few of these reasons and a few remedies.

CHAPTER I

THE ABSOLUTE NECESSITY FOR PROPER TECHNIC

All therapy resolves itself, in the ultimate analysis, down to a question of reactions. When it is realized that no repair, no matter how slight, can possibly take place in a living organism without at least some degree of inflammatory reaction intervening, it at once becomes evident how vastly important it is to have at hand a variety of safe, sure, and controllable means with which to initiate, accelerate, retard or damp out inflammatory reactions or control such inflammatory changes as should normally take place in the resolution of a given pathologic condition. When, in addition to controlling the local reactions, these same remedies can be used with a different technic to produce profound general reactions, both physical and chemical, it is seen what a wide range of indications the remedies in the physical field cover, because the physical remedies do possess these properties to a high degree. *No other therapist has a better variety of remedies more absolutely positive in action; susceptible of more accurate localization; better adapted to delicacy of control; less empiric in character or of greater efficiency, where existing indications can be met, than has the physiotherapist.* Used alone without proper regard for the aid that can be given them by medicine, surgery and laboratory, they are just as much hampered as are medicine, surgery and laboratory when used without them. Taken together they constitute a therapeutic practice that has never yet been, and, in my opinion, never will be, equalled.

In physiotherapy, as in drug therapy, the effects of certain remedies may be accentuated and prolonged by administering with them or after them certain other physical remedies, or, certain secondary and undesired reactions can be prevented or neutralized without impairing the primary reaction by preceding or following the one designed to give the primary reaction

with other physical methods. The method of *combining* them for maximum good action with little or no undesirable effect constitutes an art. The actual method of *applying* them to very best advantage has been reduced practically to the *status of an exact science.* The word "technic" as used here is intended to cover both the combining of these remedies in their proper sequence and the detailed method of administering them to secure best results.

Given a properly constructed outfit, a knowledge of exactly what reactions should be produced, the order in which they should follow each other and the intensity of each, and *failure will still result* unless certain procedures are followed. The reason is that manipulating a given machine one way will produce one kind of a reaction and with exactly the same hookup but different handling it will produce a very different or, in some cases, exactly opposite effect. The technics given here are based upon results secured by building upon the physics and biologic reactions involved and by trying every variation on many cases of a given kind and checking results. I spent some eighteen months in a large general physiotherapy apparatus factory and laboratory doing experiments constantly with the x-ray and other outfits, studying the causes of the trouble on outfits shipped in for repair, shooting trouble by mail or telegraph for doctors at distant points and gaining a broad general knowledge of the physics and mechanics of the various modalities. This experience, coming as it did after many years in practice as an electrotherapeutic specialist and just before my entrance into the World War, was an invaluable one to me and enabled me to explain successes and failures alike. The veil of mystery which had always surrounded the use of electrical modalities was torn away. They were found to be simply *physical* remedies each with one or more dominant peculiarities, susceptible of exact use for exact effects, the effect depending upon the technic used in applying the remedy, the stage of the pathology present, and the reactivity of the individual undergoing treatment.

The necessity of properly administering a physical remedy after it has been decided that the indications call for its use

cannot be overemphasized. Too often the blame for bad results is charged off against the modality when as a matter of fact it should be laid to the use of an improperly constructed outfit or to a total lack of technic or both. Some of the professional teachers of electrotherapeutics are the very worst offenders along this line. Some physicians we have heard condemn certain physical modalities when pinned down to answer questions as to how, exactly, they gave the treatments, display as complete an understanding of the requirements as the Swedish immigrant who was asked whether he had experience as a teamster, and upon answering "yes" he was sent out to grease a wagon. He was gone a long time and when he came in and was asked whether he had greased the wagon good, replied "Sure! Aye bane grease whole darn wagon except black holes in middle of wheels. They bane greasy already." These men have in many instances taken a "course" and are very indignant when told that their whole method—or lack of method—is radically and basically wrong. The very fact that some of their teachers have been sending out disciples for twenty or more years without either their own work or that of their pupils impressing the conservative but fair-minded medical profession with the value of the methods taught ought to prove to them that their technic is wrong. Not only do they fail to admit this when it is pointed out to them, but they become very vitriolic and try to fog the issue with a smoke screen of personal abuse. Attacking existing standards is never the most pleasant or popular vocation, but it is absolutely necessary in this instance if progress is to be made. I believe that this sort of thing can best be illustrated and emphasized by repeating here a paper I read at the thirtieth annual meeting of the American Electrotherapeutic Association at Atlantic City in September, 1920, and which was printed in the American Journal of Electrotherapeutics and Radiology for March, 1921.

"The Futility and Unfairness of Improper Technic in the Use of All Physical Measures"

"The greatest obstacle to be overcome in placing physiotherapy upon its rightful plane and giving it its proper place as a

specialty distinct from either medicine or surgery, yet closely interweaving with both, is the prejudice against its use existing in a good portion of the medical profession itself. That this prejudice exists admits of no argument. That it is the outgrowth of much observation of the use (save the mark!) of physical remedies is admitted. That it is fair—in the circumstances—must be conceded, but that the circumstances are unfair we shall prove. That it is rapidly dying out is a matter for much congratulation. The blame for this prejudice ever having existed must be placed squarely where it belongs, upon the shoulders of unsuccessful users of physical remedies.

"The profession at large can hardly be censured for judging the different modalities by the results following their use, and these results in a very large percentage of cases were either nothing or worse. Too often the neophyte in the use of physiotherapy, after many disappointments in favorable results, joined with his critics in the cry, 'There is nothing in it,' or 'It is capable of doing much damage in certain cases.'

"It does not greatly strain the imagination to picture the intense prejudice that would have arisen against music at first had each purchaser of a musical instrument at once started upon a concert tour without waiting to acquire a technic and had each one given it up in disgust when the public failed to respond, yet this is a practical parallel to what has happened in the physiotherapy field, the medical profession taking the place of the public in the simile.

"In my experience of a year and a half as technical expert and consultant for one of the largest manufacturers of all kinds of physical appliances, I could quote you dozens and hundreds of letters from users of these outfits asking questions that betrayed an utter lack of understanding of some of the simplest basic principles without a knowledge of which successful use would be impossible or at best, in an occasional case, accidental. The records proved in most of these cases that the Doctor had purchased the outfit months or even years before. It would be a waste of time to sympathize with these men were it not for the fact that most of them had purchased their outfits in entire

good faith, having been led to think that about all they would have to do would be to press a button and the appliance would do the rest and for the further fact that their failures not only embitter them but are invariably accepted by the rest of the profession as proving the worthlessness of the modality in question.

"Before a surgeon's statistics are accepted as reliable and as proving or disproving the value of certain procedures he must establish himself a reputation as having more than the average skill, judgment and honesty, and this he cannot possibly do without tremendous effort in study, research and practice. In other words he must acquire a good technic and this requires a thorough understanding of every factor influencing the final result. To build a technic in physiotherapy demands the same intimate knowledge of all these factors except the skill with the knife and instead of this you have a wide assortment of physical remedies, each acting in its own peculiar manner, some comparatively simple and some extremely complex. Why should not physiotherapy be judged as is surgery, not by the failures of the novice or of the irresponsible who claims the earth for it, but by the results of men of experience and ability? I believe that a recognition of the fairness of this is beginning to make itself felt and is one of the reasons for the fast diminishing prejudice now evident.

"All this is to preface the simple statement of the fact that good results from the use of physical remedies are not possible without the use of a proper technic. Physiotherapy is a highly specialized and very large section of medical practice and before a man may acquire proficiency therein he must ground himself in all the branches requisite to success in general medicine or surgery, such as diagnosis, prognosis, anatomy, physiology, pathology, bacteriology, chemistry and a host of other subjects, and last, but by no means least, must have intimate knowledge of the actions of the various physical remedies upon living tissues both in the normal and abnormal states. This latter could very well be called applied physics.

"Contrary to the not unusual idea that if a man has failed to

make good elsewhere on the staff he is good material from which to make a director of physiotherapy for the new department being established, it is a fact that the only man who will do is one who has proved himself a keen student and successful practitioner. I know of no other specialty so absolutely demanding the broadening influence of years of successful general practice as that of physiotherapy and I can safely predict failure in this field for any man not intelligent or energetic enough to succeed in general practice. And the fact that a man is successful or even famous in some medical or surgical line does not mean that all he has to do is to purchase the appliances to become a successful physiotherapist. It means only that he has qualified for entrance, not that he has graduated. The tendency for men successful in other medical or surgical lines to take it for granted that they are thereby fully qualified to prescribe or practice physiotherapy and judge of its merits by their own success or failure is not nearly so rare as it should be. Prescribing physical remedies is quite different from practicing physiotherapy and of the two, prescribing is far the more difficult. Non-medical persons can often be made into trained technicians but never into successful prescribers. The technic is a science which can be taught, but the prescribing is an art which, like music, can only be acquired by faithful practice.

"The man who is afraid of criticism; of being called radical because he uses something before untried; who stays whipped; who thinks that the treatment given in the average textbook is either up-to-date, final or satisfactory; who accepts the oft repeated dictum that 'Expectant treatment is the best in this condition' or worse, that 'No real help can be rendered'; who cannot or will not try to reduce the particular pathology in hand to its simplest physical factors and study out some physical remedy or combination of physical remedies and attempt by their use together with indicated medical or surgical aid to modify this abnormal state or reduce it to the simplest of all states—the normal—had much better stay out of physiotherapy and trouble and try something easy.

"As illustrating the great tendency of good men to condemn

physiotherapy 'after a fair trial' I will cite a recent occurrence. I had been invited to read a paper on general physiotherapy before a District Medical Society and of course went into some detail on the various modalities. When the discussion opened, an orthopedist of a great deal more than local repute arose and discussed it as follows: 'I can agree with everything the essayist has said with one big exception. I cannot admit that diathermia is of any value in orthopedic conditions—in fact in most instances the reverse is true. I purchased a diathermia outfit and tried it out on a wide variety of cases and my conclusions, as well as those of other orthopedists who have tried this method, are, as before stated, that it is either of no value or distinctly harmful.' Of course I knew his story before he had told it, but to bring out a few important points I wished him to tell it to the convention. When I started to close the discussion I remarked that there was apparently a wide divergence of opinion and wondered whether the facts could not be better brought out by an exchange of questions and answers than by a one-sided reply such as gives the advantage to the man having the last word. He was very fair and stated that he had no questions to ask—he was satisfied—but that he would gladly answer any that I might have in mind. My first one was, 'What was the make and model of the diathermia machine used in your work, Doctor?' In reply he named a machine that while fair for vacuum electrode work and autocondensation was totally unsuited for diathermia and with which even an expert could not have done successful work. My next was, 'What technic did you use in giving the diathermia treatments?' He was *surprised* that a technic was considered necessary, but stated, after another question as to how he set the machine, 'The man from the factory that set up the machine showed us where to set the *pointers* and we used it just as he told us.' Here was a man, eminent in his own field, who was condemning one of the most valuable of physical remedies because of his failure from lack of technic and the knowledge that the appliance that he had was incapable of doing the class of work for which he had purchased it. Naturally the salesman who took his order was

not going to tell him that the machine was not suited for his work (if he knew it himself, which I very much doubt) and how could a mechanic who hadn't the slightest idea of the many factors entering into the making of a proper technic teach a man something he, himself, never suspected had an existence? When I started through the various steps in the giving of any except the most simple diathermia treatments the Doctor's face was a study and before I had finished he jumped to his feet and made the following request of the President: 'Mr. President, I wish to ask permission to have all my remarks deleted from the record. I should be very much ashamed to be quoted as condemning diathermia in the light of what I have just learned,' and when the stenographer turned back and began to cross out his remarks he further stated: 'I think perhaps instead of just x-ing out those remarks that you had better tear them out completely. They might get into print.' He led the convention in a hearty laugh and thus was one more powerful, conscientious objector eliminated. It is seldom that we have such a fine opportunity to demonstrate to a critic just where the causes of his failure arose, but instances of where men good in other lines have condemned physiotherapy after what they firmly believed had been fair trials might be multiplied by the thousands. Not all physicians are so broad as was this man and some of them go on through life savagely criticizing physiotherapy in spite of any proof to them as to where the cause for failure lay.

"Ever and anon an article appears in the current medical press by some prominent man or prominent men purporting to prove that physical measures have no beneficial effect whatever in the treatment of certain conditions. If we admit that they used the very best physical modality to accomplish the wished for result and that they used the very best technic in applying it (they practically always state that this was the case, although very, very often their only claim to being physiotherapists is their possession of the apparatus and that most often borrowed) then we must admit that their conclusions are sound. The pity of it is that these articles nearly always come out in some journal with a circulation high in the thousands and read by the

profession generally and the refutation comes out—if it comes out at all—in some journal read almost exclusively by physiotherapists who as a rule do not need to read the answering argument to know the fallacy of the original. It avails nothing to protest that this is unfair to physiotherapy. It is at present a fact and is due mainly to the unwillingness of the publishers to print things that run counter to the opinion of a large portion of their readers and, we fear, in not a few cases to the decidedly sarcastic tone of the answering article. What we are striving for is to overcome this prejudice in the medical profession and secure a fair trial by a dispassionate jury and anything in the nature of vitriolic retorts, even though true, serves but to inflame further and not to sedate.

"Another point in technic and a most important one, is the proper blending of physical remedies. Rightly combined and sequenced, physical remedies will often amaze even an experienced user. We have space to cite only one example. It is now quite generally accepted as a fact by physicians that one physical remedy—the x-ray—has an inhibitive or destructive effect upon neoplasms but the amount of ray that may be used is limited by the destructive skin effects. This limit, in spite of filters, crossfiring and other expedients has been reached and to go beyond the standard dose means a burn. Yet by combining this physical remedy with another used to full effect—the ultraviolet or actinic ray—enormous overdosages of the x-ray may be administered with impunity. The ultraviolet ray besides antidoting the destructive skin effects of the x-ray to a large degree, and thus preventing a burn, is the best treatment possible for a roentgen burn, even after it has appeared. This combined technic opens up wide possibilities in the roentgen therapy field.

"We should hate very much to drop from our clinic any one modality, for in many cases where its use alone would not be productive of curative results the simple combining of it with some other mode supplies the very thing that was lacking and converts failure into success. The man who attempts to do physiotherapy with only one remedy or class of remedies is sadly handi-

capping himself and his many inevitable failures will not only discourage him but are sure to react against the physical field as a whole.

"At the risk of being accused of moralizing we are going to sound a note of warning. Not a little of the prejudice before mentioned is due to lack of tact on the part of some physiotherapists. Tact is just as essential to success in physiotherapy as technical skill and professional knowledge—in fact, if we were called upon to list the absolute requirements for success in this line we would place tact above all else. It is unreasonable to ask a successful physiotherapist not to become enthusiastic, but certain kinds of enthusiasm are constructive and other kinds are destructive. We would have no quarrel with any one who called us a mild or constructive radical, but would fight readily should he designate us a "Red" or destructive radical. The quacks, as usual, have done and are doing everything in their power by their blatant claims and barren results in the physical field to discredit it and disgust the regulars. We cannot prevent this but we can refrain from adding to that sentiment by keeping our enthusiasm within bounds and avoiding the making of sweeping claims sure to antagonize our medical coworkers. Gaining their respect and confidence requires first producing results and then the exercise of much tact in not overemphasizing our part. Best results can only be secured by taking advantage of every bit of help it is possible to get from the surgeon, internist and laboratory man—we need their help as much as they need ours—and they will neither aid us nor allow us to aid them if we keep them antagonistic. We should be satisfied to be the third leg of that great tripod which elevates the practice of medicine so immeasurably above all the makeshift structures imitating it and not essay to be the whole tripod. These three legs—Medicine, Surgery and Physiotherapy—have each their own function, each dependent upon the other and indispensable if the present high plane is to be upheld. Our wisest course is to help strengthen instead of weaken the other legs and develop our own, refraining from anything resembling destructive radicalism."

CHAPTER II

EXAMINATION OF PATIENT

It should go without saying that no case would be started on a course of physiotherapy without a most complete examination having been made. Physiotherapists in the Army, Navy or Public Health Service are fortunate (or unfortunate, if looked at from one viewpoint) in that practically every case referred to them from the wards or other services comes in with a complete diagnosis already made and a complete clinical case history already written up. It has always been my practice to lay a book or other object on the case history, proceed to examine the patient just as if no information whatever were available except what I discover, have the x-ray or laboratory findings before me and make a diagnosis in my mind, then open up the case history and see whether my diagnosis agrees with that given in the case history. If it does, well and good; if not I start investigating and finally have a conference with the ward surgeon and his chief of service and keep at it until we get together. We have one decided advantage over doctors in private practice and that is that if we wish a complete roentgen report, including a gastrointestinal series, or if we wish a blood count or chemistry test done it costs no more than the trouble of making out a certain form asking for it. Invaluable information is often afforded by this procedure. It is very much worth while from another standpoint even if it gives no definitely new information; it establishes a record of conditions at the start of treatment and gives a starting point from which to measure progress. In truth, two of the great factors in the conversion of large numbers of physicians to a belief in the efficiency of physiotherapy were, first, that the diagnosis was never under question, they—or their service and their laboratories—having made it themselves, and second, that the case was under their observation for the whole period of treatment and they had daily and hourly opportunity to check up results.

As in all other therapy, the first requisite to success in physiotherapy is a correct diagnosis. When this is made the physiotherapist must not rest here. He must not only be able to picture clearly the pathology present, but must be able to decide at what stage of progress it is at the present moment; just what would be the first change in the part if the pathology were to start resolution; what each succeeding change would be; how to produce it in the proper degree, control it, time it, etc.; to

Fig. 2.—A typical "sick call" hour line-up. Patients from the various services awaiting examination and assignment to the operators in the different sections of the physiotherapy service. The first wheelchair case is a beriberi paralysis, the second one an osteomyelitis of tibia and fibula, others are neuritis cases, nerve injury cases, arthritics, hemiplegias, etc. The cases were almost equally divided between the medical and the surgical services.

decide whether the reserve vitality or reactivity of the patient is sufficient to take care of the extra products formed in or absorbed into the blood as the result of the arbitrary application of these physical remedies, and, if not, whether the time element in the prognosis will allow of any adequate measures being undertaken with a view to building up the patient's reactivity

to a point where it will stand the strain, etc., and, above all else, *know and remember* the potentialities of each of his remedies singly or in combination and their limitations as well not only that he may not ignorantly start something that will result in disaster, but that he may not play along, impotently, with a curable stage until it becomes incurable. Because of his enthusiasm—and he will become enthusiastic if he really qualifies

Fig. 3.—Office examination. Orthopedic surgeon assisting. This is the final stage of a particularly resistant bone graft case. The grafts became infected, were replaced and started sloughing a second time when the case was sent in for physiotherapy. He received diathermia and local and general ultraviolet ray applications. The progress of the case is shown in the two x-ray plates at the top left of the picture. The left plate shows the grafts (infected) and the lack of callus between the ends of the bones. The right plate taken five and one-half months later shows the almost perfect union. At the time the photograph was taken he was receiving only the ultraviolet ray and the leg had been placed in a rigid cast. Sedative diathermia was used until the infection was eliminated, then stimulative diathermia was substituted for some weeks and then the leg was placed in a rigid cast instead of a divided one and the diathermia discontinued.

in physiotherapy—he should never make the mistake of ignoring or decrying the value of any other therapeutic procedure, medical or surgical, which has proved its worth. The doctor who reads

any passage in this work as meaning to scoff at *economical* medical or surgical procedures certainly is reading into that passage a meaning never intended by the writer.

If the reader is a good diagnostician, it is unnecessary to tell him how to examine a patient. If he is not, it is a hopeless task to *attempt* to tell him here. Our only object in inserting this chapter is to emphasize the absolute necessity of the physiotherapist working *with* his medical, surgical, and laboratory confreres and not against them.

It is not enough to determine the exact character of a pain; whether it is neuritic, neuralgic or myositic, etc. The doctor who would persist in trying to clear up a neuritic pain in an extremity by applying physical remedies to that extremity when a few moments' examination of the nerve at points nearer the spine would have made it plain to him that the real trouble was a neuritis at this higher point, is not doing himself, physiotherapy, or the patient justice and will fail just as surely as the first fireman would have failed in attempting to control a fire if he had stood beside a burning building and played large streams of water, not into the building itself but clear over the building, through the sheets of flame rising above it. If he had had no capacity for thinking, no originality or curiosity to see what would happen if he directed water nearer the source of the flames instead of at their tip, or if he had been so afraid of criticism that he would not dare try something not previously tried and proved good by other firemen, he probably would have promulgated the dictum that water was of no value in controlling fire and that the draft created by the passage of the stream through the flames undoubtedly tended to increase the combustion, therefore water is contraindicated in the presence of fire, etc., and we would now be fighting a small fire by moving all objects out of all buildings in a radius of several blocks, dynamiting or treating the blaze "expectantly" by hoping for a change of wind and for rain or, in other words, allowing nature to take its course, never realizing that a single physical law—that of gravity—was the only difference between nature's successful application (when the rain *happens* to fall at the psycho-

logical moment) of water and our own unsuccessful effects with the same natural remedy. This may sound like a rather far-fetched attempt at sarcasm, but I assure you that it is not. It is a very *mild* statement under cover of a simile of a very important truth. We repeatedly see physiotherapy—so-called—applied in this manner by men who *should know better* and later they come out with a statement that physical remedies are of no avail or are even contraindicated in these conditions. A very heavy responsibility indeed rests upon the shoulders of any medical man who assumes to condemn physical remedies without proper trial or without the most painstaking and careful study. Not only is he denying his patients any benefit that might accrue from an intelligent use of these remedies *under trained medical supervision* and by his example causing numerous other medical men who look to him for guidance to do the same thing, but he is handing over to the irregulars the most valuable section of the therapy field and practically forcing all patients who need and desire physical treatment to resort to these sources to obtain it. He is literally driving patients to the irregulars. These patients are intelligent enough to prefer receiving physical treatment from *medical* men but, where this is not possible, have no hesitancy in seeking it elsewhere.

CHAPTER III

CLASSIFICATION OF PHYSICAL REMEDIES

Physiotherapy, as the name states, is the use of physical remedies in the treatment of disease or disability. Under the head of physiotherapy would come all remedies not medical or surgical in nature such as massage, manipulation and exercises in all forms, all electrical treatment currents, all forms of heat and cold including hydro application, all forms of radiant energy including radium, x-ray, ultraviolet ray, the visible ray spectrum and the ultrared rays, etc., mechanotherapy, occupational therapy, suggestion, etc.

The various physical remedies are grouped under four general heads. This grouping is not absolute—only relative—as many of the remedies will fall under two or more headings, but they are listed under the head into which class their prodominant action would fall. This grouping has its faults but is necessary in order to give a quick general view or classification of the various physical remedies. These general headings are:

Thermal
Chemical
Mechanical
Electronic

Thermal.—The remedies coming under the head of thermal would be the three forms of heat: Conductive, convective and conversive. *Conductive heat* is heat applied to the body by contiguity and would include all such applications as poultices, hot water bags, various hydro applications such as immersion baths, contrast baths, whirlpool baths, the various sprays, douches, etc., hot sand or mud baths, hot and cold packs, etc. *Convective heat* is heat thrown onto the surface from some outside source such as radiant, superheated air from electrically heated coils, gas or oil burners, etc. *Conversive heat* is energy converted into heat in the tissues themselves by virtue of the resistance of the tissues

to the passage of oscillatory high frequency or heat waves through them. This form of heat will be discussed fully and the basic laws given in a separate chapter.

Chemical.—The physical remedies coming under the head of chemical would be the galvanic (unmodified), the constitutional effects of the ultraviolet ray and certain ionizing effects of the x-ray.

Mechanical.—Under this heading would come massage, manipulation, exercises, (active, passive, resistive, specific curative, etc.) mechanotherapy and mechanical vibration and such electrical applications as most of the static modalities, the faradic currents, the rapid or slow galvanic sinusoidal, and the interrupted galvanic, especially where the ordinary type of so-called rheotome interrupter is used and the polar effects are negligible.

Electronic.—Certain physical remedies, such as static electricity, because of their predominant effects, fall under the heading of mechanical modalities, yet their use is followed by results that cannot be explained by any theory that is based upon the mechanical effects produced. Neither can these particular effects be produced by any other mechanical action whatever nor by any other electrical device except the static current. The static current being an extremely high voltage low milliamperage current, its passage through living tissues is not followed by the formation of heat or chemical reactions in demonstrable quantity yet the clinical reaction can be foretold with certainty. A chemical reaction from an electronic standpoint is a very massive affair, thousands of electrons in millions of atoms participating, yet the difference between a non-functioning atom and one functioning perfectly may be so slight as the gain or loss of a single electron. We know the constitutional effects of massive doses of the x-ray—say through the intestines—and know the dosage necessary to produce these reactions in various degrees up to a lethal dose (on dogs) yet no research laboratory has been able to tell us exactly how or why these reactions follow such dosages. We also know the effects of ionizing dosages of x-ray. The selective absorption of certain wave frequences of the x-ray or radium or of the vibratory effects following the passage of a

very small volume but exceedingly high speed stream of electrons (such as the static) through the tissues by certain cellular elements may be found to explain both phenomena. The question as to how, exactly, the reaction takes place is still open to debate, but not the fact that it can be produced at will. The answer that the effects produced can be called psychic is also beside the question as they can be produced as readily in a man who protests loudly that he does not wish to take the treatment as he has had it for long periods before this time with only bad effect as they can in a man who believes in the treatment and is willing to take it. In fact, they can be and have been produced upon unconscious patients. The statement is often made that most of the effects following the application of electricity in therapy are psychic. This fallacy will never be enunciated by any physician who has made even an *elementary* study of physics.

CHAPTER IV

FORMS OF HEAT

Heat is used in one of three forms:

1. Conductive.
2. Convective.
3. Conversive.

Conductive heat is heat applied in contact and transmitted by conduction from the heated substance to the one it is desired to influence. A copper wire having heat applied at one end will gradually heat up further and further from the point of application. This spread of heat is by contiguity, and if the wire be cut and the two ends separated a small space then the distal end will not heat from the proximal. If a cold stream of water be trickled on the wire a few inches back of the point of heat application the wire will not heat beyond that point; the heat is taken up and carried away by the water as fast as it reaches this point. Hot water bottles laid upon a surface, hot baths, compresses, hot sand and mud baths, etc., are all forms of applying conductive heat. The action of the first two forms of heat is so well understood by physicians that I shall not consume space discussing them at length.

Convective heat is heat from some source not in contact with the body thrown onto the body by radiation or carried to the body by currents of air. Radiant light and heat from incandescent sources is an example of the former and superheated air from gas burners, electrically heated resistance wire, etc., an instance of the latter. The use of conductive and convective heat from natural sources for treatment purposes is as old as human history. The action of these two forms of heat, locally applied is to heat up the surface and superficial tissues and, if applied intensely enough, to bring about certain reflex vasomotor changes which may benefit distant parts. The more intense the local application the more urgent is the local call sent out for

quantities of blood to be rushed to and through the parts to carry away as much of the excess heat as possible and prevent damage. For this reason it is impossible to heat up deep lying structures by simply increasing the degree of heat applied or prolonging the application. The fact that the point of greatest heat from the application of radiant light and heat is the proximal surface and that the application is so easily made and that

Fig. 4.—Application of radiant light and heat from a 1500 watt bulb outfit precedent to massage.

considerable surface can be covered makes this form of heat of great value for local surface applications. For heating the skin alone it is better than diathermia and in reality for superficial work it is a combination of convective and conversive heat, the rays penetrating a *short* distance and there being converted into heat. There is no doubt whatever that enough light rays to affect light sensitive plates can be made to penetrate inches of tissues but such a relatively small proportion of the whole radi-

ated energy has this penetration that its use for heating any except the most superficial tissues is far inferior to diathermia. It has its points of superiority and its limitations and these should be kept in mind. There are several makes of high wattage bulb lamps and the improvements recently made in these outfits makes them a very desirable addition to any therapy clinic. The rays should *not* focus and, on account of the extremely high temperature such bulbs reach, ample provision for cooling should be made. Some of these lamps are beautifully constructed, have a good range of adjustment, etc., but until a bulb is constructed that will stand such usage it should be remembered that they are very apt to burn out if the bulb is raised more than forty-five degrees from the vertical, as this raising of the bulb beyond that point interferes markedly with the circulation of air around the bulb and results in overheating. In buying bulbs for these lamps be sure to give your *exact* voltage as a difference of five or ten volts over the voltage rating of the bulb will shorten the life of the bulb materially. If you have a 120 v. current secure a 120 v. bulb. Remember, also, in using the 1500 watt lamp on the 110 v. current that such lamp pulls over 13 amperes and should not be used on very small wire circuits or where other outfits are pulling much current. The fuses should be at least 20 amperes on the circuit. The application of ice is simply minus heat and heat is abstracted locally to be replaced by the circulating blood. The local and general effects will be described more fully in the hydrotherapy chapter. The application of radiant light and heat from artificial sources to the body generally is followed by a drop in the leucocyte count which lasts two weeks or longer and it is for this reason that we do not use or advocate its use as a measure to precede *general* ultraviolet applications. In x-ray "burns" and where intense *local* effect is desired, we do use intense radiant light and heat applications from the 1500 watt lamp to precede the ultraviolet light. The general application of superheated air by means of a large body applicator is followed by a marked leucocytosis in addition to its stimulative effect upon the eliminatory organs and is a measure of great value in extreme acidosis. The use of superheated air to ar-

thritic joints, teno-synovitis with effusion and other local inflammatory conditions formerly gave great relief in many cases but the whirlpool bath and especially the sedative, absorptive form of diathermia now gives more consistent and better results.

Conversive heat is energy converted into heat in the tissues themselves. This is the form of heat that results in the tissues when a diathermia current is passed through them. The diathermia current is the d'Arsonval current and when passed directly from one metal cuff or plate to another is called direct diathermia, or as it is most often given in this form it is simply called diathermia and if given in any modified form is called indirect diathermia, modified diathermia, etc. The fact that the heat from the passage of this current is formed *in the tissues* as the energy transverses them and is not introduced from a heated or radiant source; that it can be introduced so gently and gradually as not to arouse the reflexes at all or at most only partially; that the formation of heat is not greatest at the surface where the electrodes are applied but that the point of greatest heat is somewhere in the tissues between the electrodes, and can be localized very accurately by varying size of electrodes; that fibrous tissue, the one tissue we most often have to combat, having a high resistance on account of its lack of vascularity heats up faster than normal tissue and for the same reason holds its heat better; that the formation of heat is instantaneous and constant in such structure even in the presence of an arterial hyperemia; that such fibrous tissue, if new, will often disappear under no other application than diathermia and, if old, can be softened up, made easier to stretch, devitalize, macerate and remove by subsequent massage, manipulations, sparks, etc., and that such heat makes these procedures much less painful and at the same time acts as a wrecking crew to clear all inbound and outbound roads for the rapid removal of detritus and increases their capacity by dilating the vessels and lymph channels; that it is well known that normal tissues will react and recover from higher degrees of heat and bombardment from x-rays and other longer wave lengths than will abnormal tissues and that the heating of such tissue makes it *more* sensitive to x-ray are some of the reasons this form of heat is so vastly

superior to other forms and why, where it can be obtained, it is the method of choice in applying heat. Based upon an almost unsurpassed opportunity to use, observe and compare the effects and efficiency of the three forms of heat, I would not hesitate to say that in my opinion the value of these three forms—conductive, convective and conversive—would rate about one, five, one hundred, respectively.

CHAPTER V

HIGH FREQUENCY—GENERAL CONSIDERATIONS

What is a "high frequency" current and wherein does it differ from a low frequency current? Believing that a homely illustration which will clarify your point and make it easy to understand even though it may make an experienced physicist laugh because of its crudity, is better than a long scientific, but very complicated, explanation filled with formulae, logarithms, etc., which would please an abstract scientist but which would bore the average physician to death even if he would attempt to follow it, I am going to adapt the former course to put over my points. If the reader really wishes to study the subject in its minute details (and every hour put in studying any branch of physics is an hour well spent) he will find these explanations in extended form in many special works on physics, induction currents, etc. No one book is going to cover the subject from every angle and you will pick up a little information here, a little more there, and in the course of time and with study you probably will be able to correlate your data and form some sort of an intelligent idea what it is all about.

In discussing high frequency currents from a medical standpoint it must constantly be borne in mind that the term "high frequency" as used by the doctor and as used by the commercial electrician means two very different things. The doctor means a current having a frequency of oscillations measured in the hundreds of thousands or millions per second while the commercial electrician means a current having only a few hundreds of alternations per second. To the electrician a current having a frequency or cyclage of five hundred per second would be a high frequency current (his comparison is made with the common sixty cycle a second alternating current) while to the physician a five hundred cycle a second current would be a *very low* fre-

quency current and would be just as dangerous as the ordinary 60 cycle alternating current. The doctor puts his dividing line between high and low frequency currents at the point where human tissues cease attempting to respond to each impulse and this point lies above thirty thousand per second.

A high frequency current (medical) then is an electrical current having such a high rate of alternations or oscillations that living tissues do not attempt to contract under each impulse. They differ from low frequency currents in the fact that their passage through living tissues is painless, nontraumatic (under proper density of current) and beneficial over a wide range of indications whereas the passage of a like volume of low frequency current would be extremely painful, would traumatize muscles and nerves and even fracture bones and would be dangerous and deadly.

What are the steps in the conversion of a low frequency current into a high frequency current? The first step is a rise in the voltage. The 110 volt or 220 volt alternating current is put through a step-up transformer. The alternating current is used because circuits carrying it have the property of inductance. The direct current circuit has no inductive properties unless the current is rapidly interrupted and the best of interrupters have so many faults and limitations that the use of the interrupted direct current as a source of supply for x-ray and high frequency machines has practically been discontinued. If only a direct current is available it is much more satisfactory and less expensive in the long run to install a rotor-converter of sufficient capacity to meet all present and future needs. One large converter is much better, as well as much cheaper, if several machines are to be run from a D. C. source than to have a small rotor-converter for each unit. I *know* this is true as I have had much experience both ways.

The wires leading from the street current (or the rotor-converter) into the main transformer are wound around one leg of an oblong mass of laminated iron and form what is known as the "primary." These wires have no metallic connection with the iron; in fact they are insulated from it. Insulation has practically no effect in stopping the action of the magnetic lines of

force (induction) as it acts through all known insulators. On the opposite side of the core or oblong laminated iron mass is wound the secondary. The turns of wire composing the secondary are also insulated from the core. The magnetic lines of force generated by the passage of an alternating current through the primary circulate in this iron core and, by induction, generate a current of electricity in the secondary. The voltage of this secondary current depends upon the ratio of the number of turns of wire in the secondary to that of the primary. If the number of turns in the secondary were less than in the primary the newly generated current would be of less voltage than the primary current and the transformer would be called a step-down transformer. The wires from the secondary form a circuit in which is included a spark gap, a condenser and the primary of a second step-up transformer where the voltage is again raised to form the Tesla of Oudin current. Where no *special solenoid* or coil of wire is provided (d'Arsonval solenoid) this second primary forms the d'Arsonval circuit. The first step in the transformation of a low frequency current to a high frequency current is simply a raise in the voltage. The primary transformer does not change the frequency at all and this *must be raised* before the current will be safe to use. This is accomplished by means of the spark gap and condenser. The spark gap is a *variable* resistance (if clean and properly made) placed in series in the secondary line and is used to compel the condenser to fill and to regulate the voltage or pressure to which the condenser must fill before emptying itself or discharging. Roughly speaking, the condenser could be called a *frequency step-up transformer.* It does not affect the voltage or amperage of the current in the secondary circuit but does act to raise the frequency. We are purposely avoiding the long, tedious descriptions of the various forms of transformers, open and closed core. wax or oil immersed, and will only state that the closed core, oil immersed type is the one generally used in the best machines. The same thing holds for the condensers. Whether the condenser is made of glass and tin foil layers, single sheets of glass covered on both sides with tin foil, glass leyden jars or mica sheets, the action is the same. The very cheap waxed paper

condenser should have no place in a high frequency outfit as it will not hold up under any heavy usage. The leyden jar type —if a good quality of glass is used—properly balanced, or the sheet mica type is probably the best.

Action of Condenser.—Suppose that we have a bank of some octaves of metal bells. Each bell is tuned to exact resonance; that is, it will be thrown into vibrations and give off sound when it is struck by vibrations of a certain wave length and intensity. Suppose that in the center of these octaves of bells, we have one large bell that can be tuned to give off the vibrations of any note in the octave—a, b, c, d, e, f, or g. Suppose that we set it to sound the note c. If we strike it sharply with a hammer or other metallic object it will vibrate freely and give off sound or waves which will strike *all* the bells in the octaves near by. Only such bells in these octaves as are tuned to give off the sound "c" or its octaves will vibrate when struck by these wave lengths. The other bells will not vibrate and will not give off sound. If we tune the large central bell to give off the wave length "a" then all the octaves of "a" in the bank of bells will vibrate and give off sound. Those bells that are thrown into vibration when certain wave lengths strike them are said to be "resonant" to that wave length. If now, instead of striking the central bell with a heavy hammer we should strike it with a small wheat straw the resulting vibration would not be sufficient to give off sounds audible to the human ear and none of the other bells, even those in resonance, would sound because the orignal impulse was not sufficiently forcible to set up vibrations. Now suppose we strike the central bell with a hammer and an instant later step on a pedal which will push a large pad against each of the bells. The sound will almost instantly die out. The vibrations are cut off and the sound ceases. When the oscillations in an electrical circuit are cut off we say that the resonant circuit is "damped" which means that at a certain point some resistance too great for them to pass or overcome is placed in their path. Suppose, now, that instead of a single hammer blow at more or less irregular intervals such as would take place were we to attempt to keep the central bell vibrating by hand we should substitute a very rapidly acting pneumatic

hammer and play it upon the bell, having the foot lever connected so that at a very short fraction of a second after each hammer blow had been struck the damping pad would shut off the vibrations and stop the sound. These recurring blows and the damping out would be occurring at a very much faster rate than the human ear could divide into separate sounds and the sound to the ear would be one continuous roar, just as images on a film screen seem to be continuous to the eye although in reality there are some sixteen separate ones per second.

In the high frequency outfit the resonant (at least it *should be* resonant) d'Arsonval circuit takes the place of the bank of resonant bells, the condenser and spark gap take the place of the rapidly acting pneumatic hammer and the resistance of the air gap takes the place of the damping pads that shut off the sound.

If we had no condenser in the circuit and only a spark gap the sparks shooting across the gap would not have mass enough to set the resonant circuit into vibration just as the wheat straw was too light. By accumulating the current in the condenser until the condenser is full and then discharging the whole capacity of the condenser at one instant we have done practically what we did when we substituted the hammer for the wheat straw. The condenser is in reality a storage battery having the ability to fill and empty many hundreds of thousands of times per second. When the newly induced current from the secondary of the main transformer starts around the d'Arsonval circuit it encounters a resistance in the open spark gap and proceeds to fill up the empty condenser. When the condenser is full the pressure (voltage) rises in the whole circuit back of the spark gap until the voltage rises to a point where the resistance of the air gap is less than the pressure and the air gap is ionized or broken down by the mass of current forcing its way across the spark gap to the rest of the circuit, where it is neutralized by the negative charge present there. When the current was rushing around to neutralize the negative charge on the opposite side of the condenser it passed through the d'Arsonval solenoid and, as in the case of any inductive current, caused the throwing out of magnetic lines of force upon all sides of the

solenoid. These lines of force are traveling in the opposite direction to that of the mass of current which crosses the spark gap from the positive side and rushes to neutralize the negative charge. When the positive charge meets and neutralizes the negative charge both charges *cease to exist* but the lines of force which were thrown out when the charge rushed through the d'Arsonval now collapse (there being no voltage variation below to hold them out) onto the solenoid and in so doing generate a new charge of current which must travel in the opposite direction to that of the generating lines of force or in the same direction as the last surge of current on its way to the negative side of the condenser so that the next positive charge is imposed upon the side of the condenser which was just negative and builds up until the lines of force have all collapsed, when the newly induced current again rushes across the gap to the other side, when the next charge is reversed in direction. The loss of energy expended in crossing the spark gap and overcoming resistance in the circuit (extremely small resistance but nevertheless there) makes each succeeding condenser discharge of a slightly lower voltage than the last one so that after a few hundred discharges the voltage generated is not sufficient to jump and that particular train of condenser discharges, all of which resulted, inductively, from the first condenser discharge is damped out. The time necessary for this complete train of condenser discharges to die down to a voltage too small to cross the spark gap is estimated at from a fifty-thousandth of a second to a seventy-five thousandth of a second. Then the ions in the ionized air of the gap scatter, another condenser discharge builds up from the voltage from the main transformer and the cycle is repeated. Thus a single condenser discharge from the voltage of the main transformer sets up an inconceivably rapid succession of condenser discharges which is comparatively quickly damped out, but the condenser is recharging at a regular rate from the main transformer so that the frequency runs up into the hundreds of thousands or even millions per second and human tissues no longer are able to separate them. Thus all sensory effects are lost except the sensation of heat due to the actual formation of heat in the tissues themselves. It is

almost impossible for the human mind to form an accurate conception of the extreme speed of high frequency oscillations. Imagine looking through a peep hole in a window at the spokes of a gigantic fly wheel. This wheel is turning at a rate that will cause the spokes to pass the window at about the rate the eye can distinguish them or about twelve spokes per second. Compared to the speed of oscillations having a frequency of half million per second (a very ordinary speed in high frequency) the passage of one of those spokes before the peep hole in the window would be as deliberate as the passage of the sun from the eastern horizon to the western and compared to a frequency of a million per second the spokes would be moving as much slower than the high frequency oscillation as the difference in the time of passage of one of them before a peep hole in the window and a full twenty-four hour day.

These two steps, the raising of the voltage and the raising of the frequency, are all that takes place if only the d'Arsonval or diathermia current is considered. If the Tesla or Oudin current is to be used then a third step must take place. This third step consists in stepping-up the voltage a second time. No matter whether a Tesla coil or an Oudin resonator is used, the end result is that the voltage of the d'Arsonval circuit is raised much higher but the frequency (which is now *high*) is not again changed. As the voltage goes up *per force* the amperage must come down in the same ratio even if there were no core or induction losses. A definition of the two currents distinguishing one from the other would read: A d'Arsonval current is a *high frequency* current of high amperage and relatively low voltage (low in comparison to the static voltage or that of the Tesla or Oudin currents) and a Tesla or Oudin current is a *high frequency* current of low milliamperage and high voltage. It will be noted that with any given set of the controls on a given high frequency outfit whether the current used is the d'Arsonval or the Tesla or Oudin current, the frequency is the same, only the voltage and the amperage varying. The transformation of a dangerous current into a high frequency current can be compared very aptly to what takes place when a very high pressure, large volume stream of water is nebulized. Before going

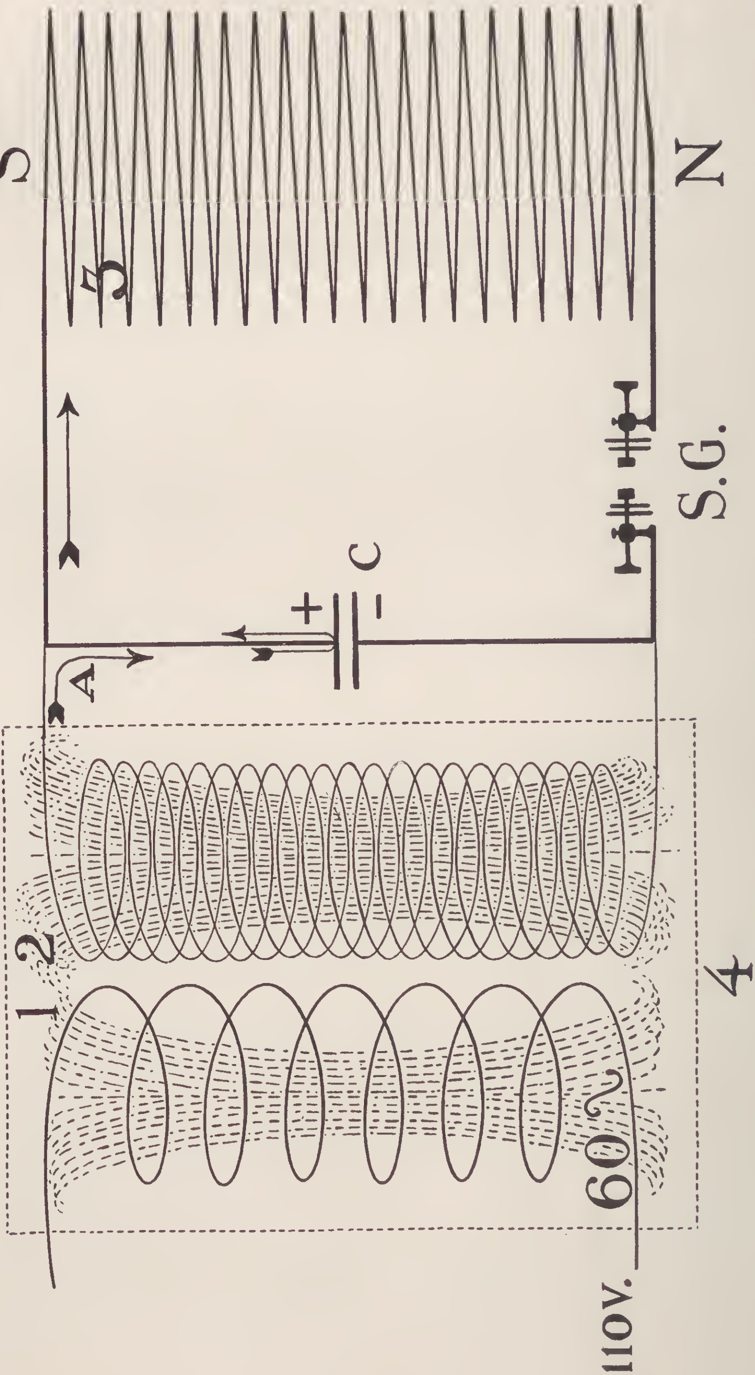

Fig. 5.

The following six drawings (Figs. 5, 6, 7, 8, 9, and 10) are to illustrate the beginning of a series of condenser discharges that result from a single charge of the condenser from the primary transformer.

1 is the primary solenoid of the main transformer; *2* is the secondary solenoid of the main transformer. (Only the circuit itself is included in these diagrams. The iron core of the transformer, the metal case, wooden cabinet, etc., are left off as their inclusion would only result in making the drawings more complicated.) *3* is the d'Arsonval solenoid (which does not have any iron core). The directional arrows around the circuit are to point out the direction of the current. The arrows inside the d'Arsonval show current direction and the ones to the right show the direction of the newly generated lines of force. In Fig. 5 the condenser is shown receiving a charge from the main transformer. When it has filled to capacity the voltage in the condenser and all around the circuit to the spark gap rises until it is high enough to begin to spray across the spark gap. The instant that this takes place the air of the gap which has up to this time been a very high resistance becomes ionized and suddenly becomes a good conductor of current and the whole charge of the condenser rushes across this path to neutralize the opposite polarity (negative) charge on the other side of the condenser. Note spark gap open in Fig. 5.

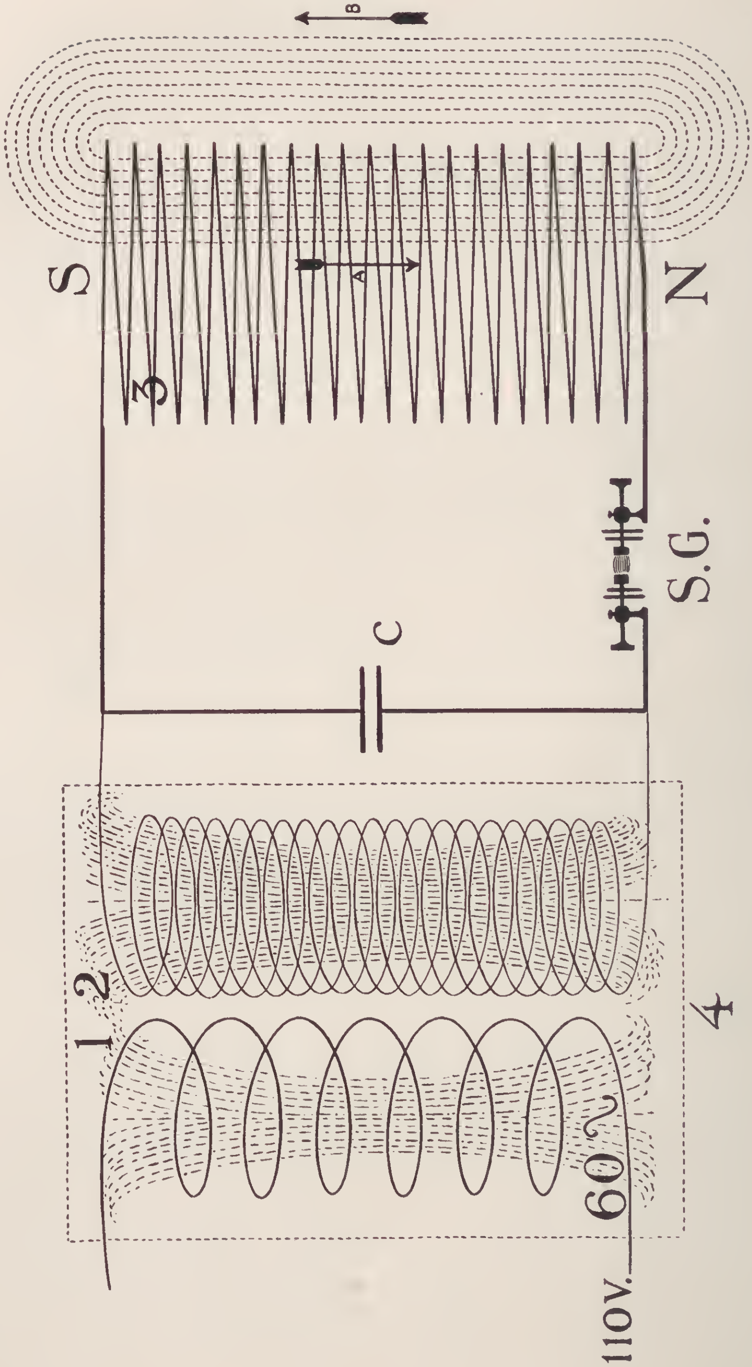

Fig. 6.

Spark gap has ionized, charge on positive side of condenser has crossed to neutralize the negative charge and instantly both charges have ceased to exist. As the positive charge rushed through the d'Arsonval solenoid it caused the throwing out of lines of force around the d'Arsonval solenoid, which lines of force always travel in the opposite direction to the direction of the generating current. As soon as the charge of current has crossed these newly generated lines of force collapse onto the d'Arsonval solenoid (there being now nothing to hold them out) and in so doing they generate a new charge of current of a slightly lower voltage than the first surge. This new charge travels in the opposite direction to the generating lines of force which makes it travel in the same direction as the original charge and so the second charge impressed on the condenser is a positive charge on the same side that an instant before had held a negative charge. This second charge follows the surge of the first charge across the spark gap so fast that the ions in the spark gap have no time to scatter and thus raise the resistance of the gap again. If the frequency of the circuit is two million per second then this second charge crosses the spark gap one two-millionth of a second after the first one. Fig. 6 shows the circuit after the first charge has gone around and before the second charge has been generated. The condenser is shown empty (no charge on either side).

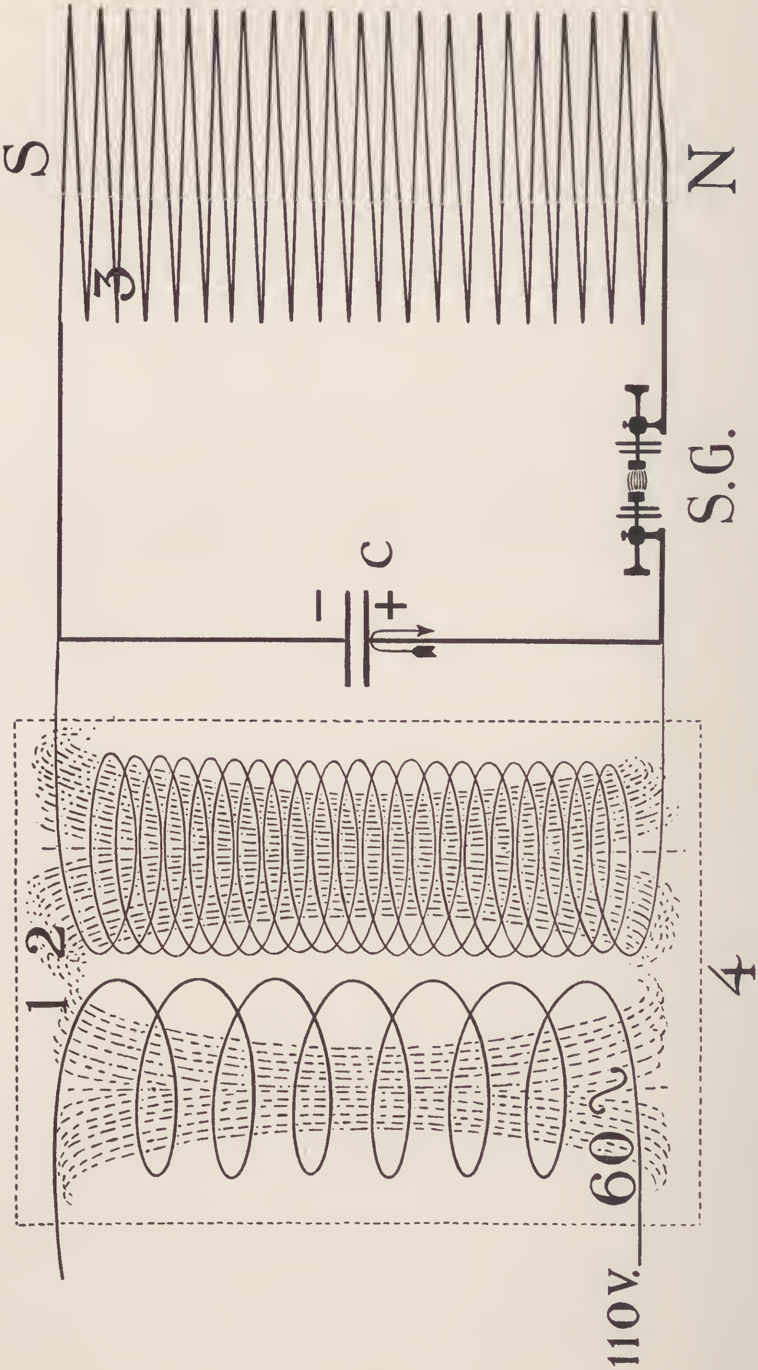

Fig. 7.

The condenser is shown satisfied (charged) by the charge generated when the lines of force shown in Fig. 6 collapsed. The spark gap is still ionized and there is practically no resistance between the positive charge on one side of the condenser and the equal quantity but positive polarity charge on the other side. Opposite charges of electricity have such a great attraction for each other that they will cross high resistances (but not too high) to reach and neutralize each other and when the generating lines of force which were driving the current to the positive side of the condenser die down or collapse there is then nothing to prevent the positive charge from rushing around to the negative and this is what takes place. On the way around it passes through the d'Arsonval solenoid again and again new lines of force are generated. The condenser is discharged by the neutralization of the two charges when they meet and the new charge generated by the collapse of the new lines of force follows and the cycle is repeated.

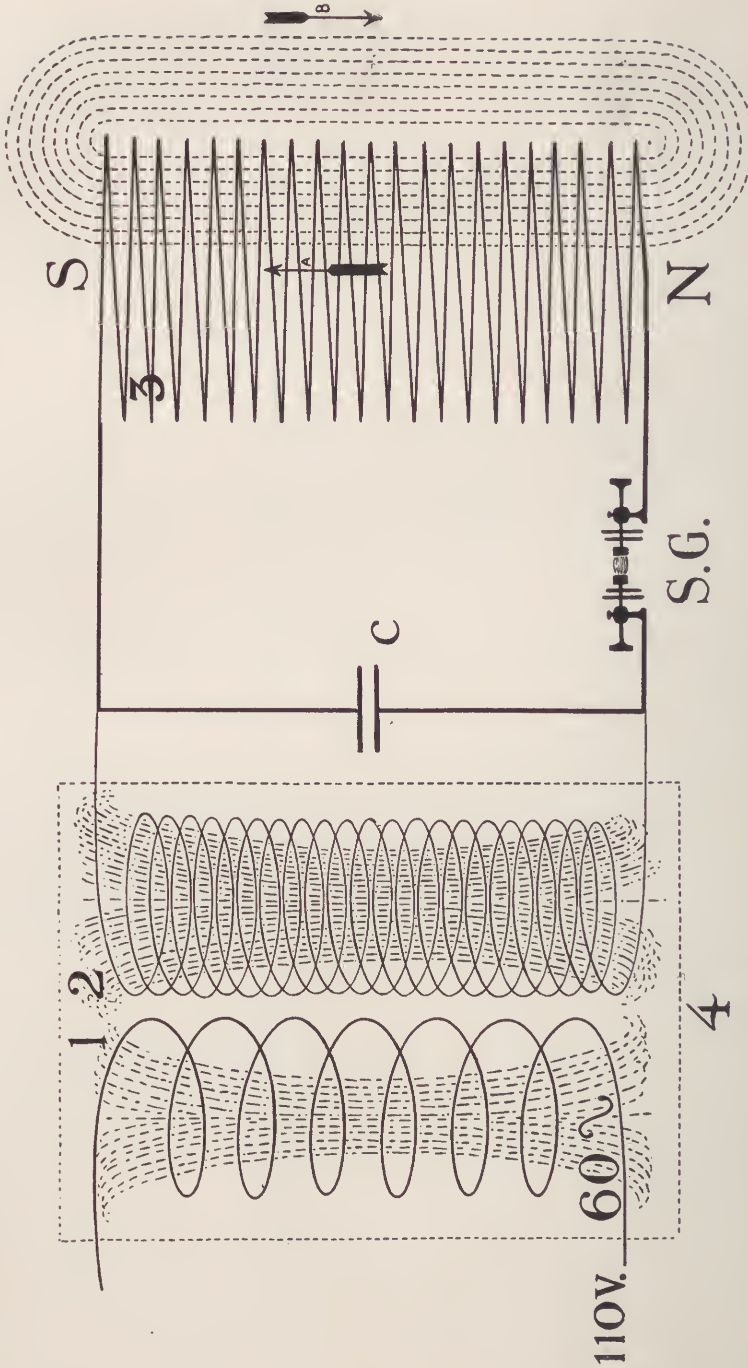

Fig. 8.

The condenser is shown discharged. The newly generated lines of force are shown just before their collapse. The new positive charge will be impressed upon the opposite side of the condenser from the one that held the last positive charge, etc. Thus it can be seen that statements that certain high frequency hookups (such as the old Rumkorf coil, resonator outfits) give a distinct polarity effect on one side of the circuit cannot be correct. No true high frequency current can have a polarity effect upon tissues as any given point in the circuit is alternately positive and negative.

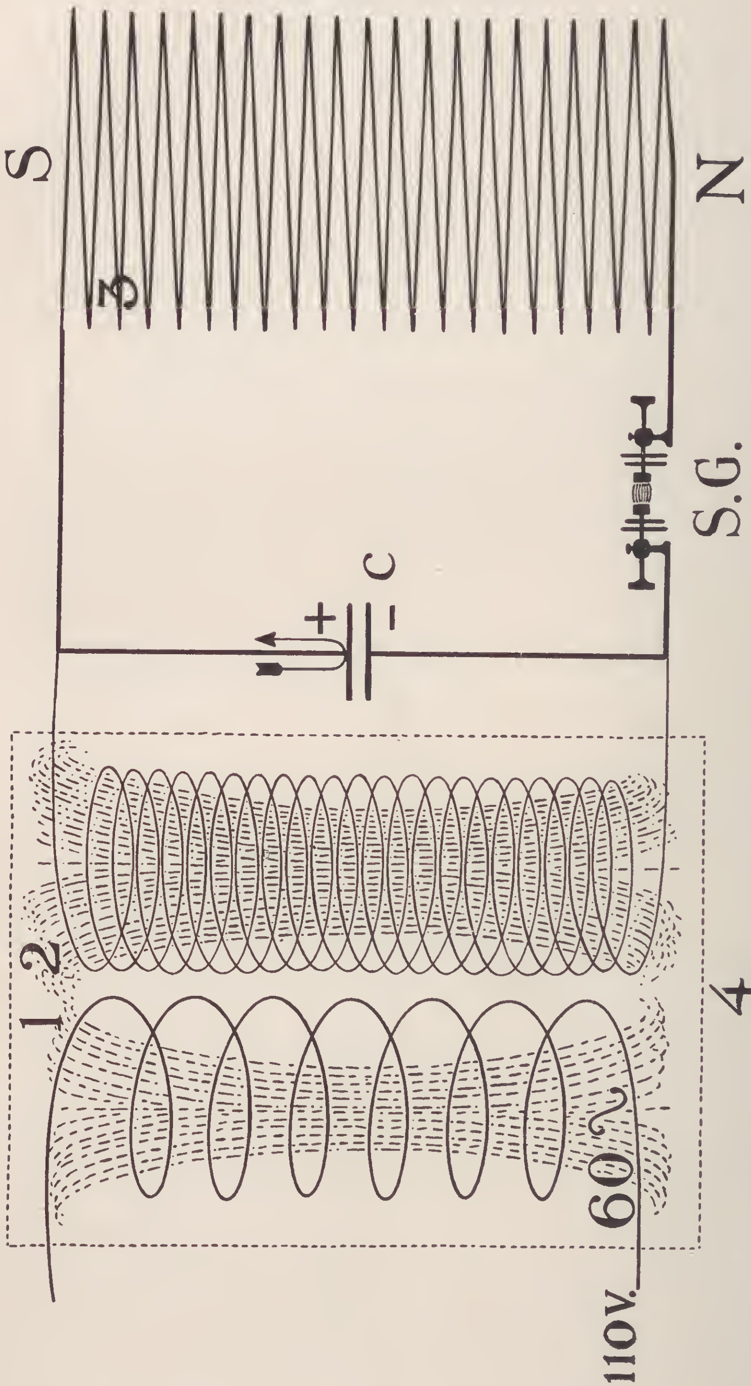

Fig. 9.—The condenser is shown charged. The lines of force shown on Fig. 8, have now collapsed and the new charge has gone to the condenser.

through the nebulizer the stream of water is extremely dangerous to life and if attempt were made to use it for the irrigation of delicate plants not only would the plants be destroyed but great holes would be torn in the soil, etc. After the stream has passed through a giant nebulizer which reduces it to a vapor so light that it will float in the air, the same stream of water can be sprayed upon the most delicate of plants with none except the most beneficial results. This holds only if the high frequency of the current is maintained. If, for any reason, the resistance in the circuit becomes such that free oscillations of the circuit are interfered with, the current ceases to be a high frequency current and becomes an interrupted high tension current or if the machine called a high frequency machine is not in resonance then the same thing is taking place. The difference between a true high frequency current and an interrupted high tension current of the same voltage is the difference between an absolutely sedative application and an intensely irritating one.

As has been shown in the use of the Lewis Jones muscle testing machine and again referred to in the chapter on the treatment of locomotor ataxia a very slight difference in the capacity of a condenser discharge or of the voltage used in charging it will make a marked difference in the ability of such discharge to produce contractions in contractile tissues. All other things being even, the higher the voltage the more irritating the discharge and therefore the greater its ability to produce contractions or cramps in the tissues. The difference in voltage from the Lewis Jones muscle testing condenser set and that from the diathermia circuit of a high frequency machine is one of several thousand per cent; therefore an interrupted high tension current (which in this case is a condenser discharge of thousands of volts instead of one hundred) is sure to set up contractions even in tissues that would not respond to the muscle testing set at all. It makes no practical difference whereabouts in the circuit the high resistance that prevents free oscillations is located if it is *in* the circuit, and this fact is one of our reasons for several of the steps in the technic of giving sedative diathermia such as lathering both electrode and skin, use of large conducting cords, metal electrodes on the skin, etc. Entirely outside of

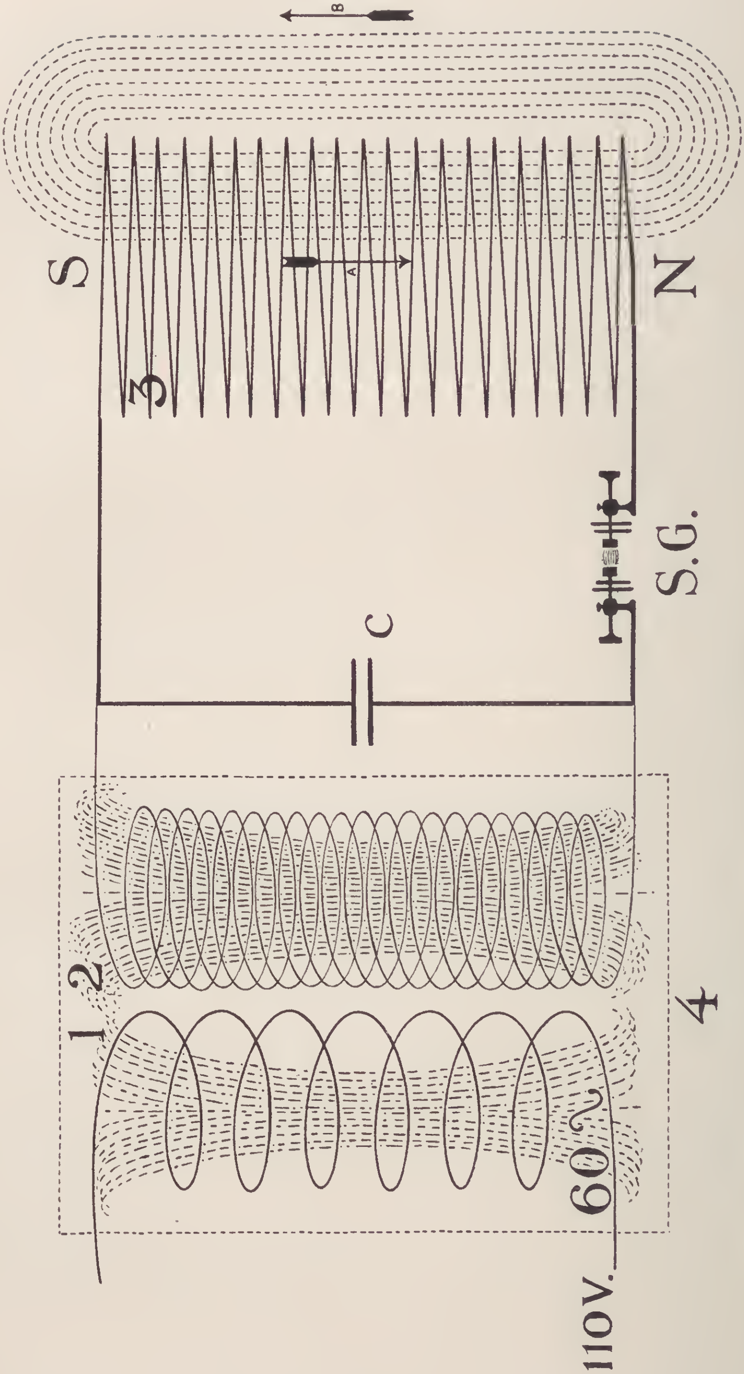

Fig. 10.

The condenser is shown discharged and new lines of force are out, etc. If the series of drawings were to be continued the next one would be exactly similar to Fig. 7 with the exception that the charging voltage is steadily decreasing on each succeeding charge. The next one would be as Fig. 8, the next one as Fig. 9, etc., until the series started by the original charge shown in Fig. 5 has died down. This entire series of condenser discharges resulting from the charge shown in Fig. 5 may consist of several hundred chargings and dischargings of the condenser before the alternation of charges stops and the time taken for the whole series to run has been estimated at from a seventy-five thousandth of a second to a fifty-thousandth of a second. The ions in the spark gap then scatter and the resistance of the gap again is high and another original charge from the voltage of the secondary of the main transformer is impressed upon the condenser and the series goes as before. If the spark gap is allowed to oxidize or if it is of wrong construction, if the resistance, inductance, impedance, etc., of the d'Arsonval circuit and the capacity of the condenser are not exactly balanced then the follow-up condenser discharges are cut off and the circuit becomes a low frequency circuit instead of a high frequency and the outfit is unsuited for sedative diathermia work.

the danger of burns from using water soaked electrodes in the giving of diathermia treatments is the fatal objection that due to the constant rise in resistance in such electrode from evaporation, syphonage, gravity, etc., the sedative quality of the treatment is rapidly converted into stimulation and the object of the treatment defeated. Under a metal electrode the sweat, instead of being absorbed into the body of the electrode and there evaporated, is held and a few minutes after the start of the treatment and before the lather has had time to dry out there is a layer of salt solution between skin and electrode which makes perfect contact, keeps down resistance and which is maintained as long as the treatment lasts.

The high resistance may be in the spark gap due to faulty design, allowing it to oxidize from too seldom cleaning it or from improper manipulation of the gap by the operator. (See discussion No. 9 under diathermia technic.)

If the machine is not resonant it may be because the internal resistance is too high from use of wire of too high ohmic resistance (this is almost never the case) or because the inductance, resistance, capacity, impedance and other factors are improperly balanced. Here is a simple clinical test that any physician can make in a few minutes and which will show lack of resonance. Given choice of two paths an electrical current will take the one of least resistance. This is axiomatic. It is also apparent that the resistance between two diathermia cuffs or plates properly placed is less than the resistance offered by an arm plus a whole human body plus the insulating properties of dry leather in shoes, the floor, etc. Apply a pair of metal cuffs properly to the biceps and the forearm or to the thigh and the calf and start the treatment, using the sedative technic. Allow the current to pass for some five minutes or more until the limb starts to warm up and the skin begins to moisten with sweat. Then approach the patient and with your bare hand touch the surface of the skin *between the two cuffs*. If the machine is a properly balanced one, all the sensation you will feel will be that of heat in the limb and you will receive no electrical shock whatever. If the machine is out of resonance very bady you will receive quite a severe shock (painful but not dangerous unless you are

afraid of it) because the current will leave the circuit and traverse your body to the ground. Let no one convince you that any such machine is a proper machine from which to attempt to administer sedative diathermia. Such a machine is very badly out of resonance. It was the giving of diathermia treatments from such machines in the early days of the war that resulted in the order being given to cease using diathermia in all orthopedic cases. As we consistently refused to use any such machine and did use proper machines it was only a short time until we had more orthopedic cases than of any other single service referred to us for treatment. Technic, of course, entered into the equation, but with the very best technic and nonresonant machines we should have failed in these cases and the order, in the circumstances, was a fair order even if we did risk official displeasure by refusing to follow it. Our commanding officer was an exceedingly fair man, but took the stand, at first, that the merit of the order was not the question, but after giving us a bad couple of hours agreed to allow us to use our discretion but warned us that we would be held strictly accountable if bad results followed our disregard of the rule. We sometimes shudder yet when we think of what might have happened if we had failed to produce the promised good results. That we did produce them is proved by several things, not the least of which is the fact that within four months we had signed requests from every orthopedic ward surgeon in that hospital asking us to give diathermia to *every patient* being sent to the physiotherapy service from their wards.

The reason that the current leaves the circuit and shorts through you to the ground is that while the resistance through you to the ground is greater than from cuff to cuff in the circuit itself, it is much less than the current would have to overcome in traversing the complete circuit back around and through the machine itself.

If this is true it can be seen why such a machine will not do good sedative diathermia work. A machine can be out of resonance without giving this test but if it gives this test it is assuredly very much out of resonance and should not be used for this class of work.

Much confusion is arising over the indiscriminate using of the term ''diathermia'' to describe both constructive and destructive applications of the d'Arsonval current. Dr. W. L. Clark of Philadelphia and others have done and are doing considerable fine work in the surgical field either using the d'Arsonval current alone or in conjunction with surgery for destructive purposes. These pioneers in the field are always very careful to say ''surgical diathermia'' or, better, ''electrocoagulation'' but I note an increasing tendency to call all destructive applications of this current ''diathermia.'' The word itself meaning to heat through and through was so evidently derived from its constructive application and the field of constructive diathermia is so much wider than its surgical field that there is no question but that the term ''diathermia'' should be used to designate constructive applications. The term ''electrocoagulation'' is more descriptive even than the term ''surgical diathermia'' and should be used, but if the term ''diathermia'' simply must be used then it is only fair that to keep from mixing up the various technics advocated, a descriptive prefix like ''surgical'' or ''destructive'' should precede the word ''diathermia.''

CHAPTER VI

DIATHERMIA

Diathermia, variously called thermopenetration, thermoinfiltration, thermosaturation, electrothermopenetration, trans-thermia, direct d'Arsonval, etc., is in reality conversive heat. Conversive heat is, beyond question, the most valuable form of heat used in therapy. Its proper and successful use demands a knowledge of the physics involved and a technic as rigid as that used in the most exacting surgical procedures. This technic seems, at first glance, to be needlessly complicated, but is in reality very simple. It is based, step by step, upon physical laws and clinical reactions.

The first requisite to the successful use of diathermia is, of course, a properly constructed, resonant high frequency outfit. Given such an outfit, the other requisites are somewhat as follows:

1. *Selection of Method* of applying the diathermia whether direct, indirect or modified and, if direct, choice of the double cuff, double plate or cuff and water method.

2. *Technic*—sedative or stimulative.

3. *Selection of Proper Electrode Material.* (Same for both technics.)

4. *Proper Preparation of Skin and Electrodes.* (Same for both technics.)

5. *Proper Application of Electrodes.* (Same for both technics.)

6. *Use of Elastic Bandages.* (Same for both technics.)

7. *Beginning of Treatment.* (Differs in the two technics.)

8. *Timing of Treatment.* (Differs in the two technics.)

9. *Proper Use of Spark Gap and Condenser.* (Differs in the two technics.)

10. *Terminating Treatment Properly.* (Differs in the two technics.)

11. *Calculating Dosage.* (Differs in the two technics.)

12. *Knowledge of Basic Laws that Apply.*

13. *Knowledge of Effects Produced in Tissues by Each Technic.*

14. *Knowledge of Indications and Contraindications for Each Technic.*

As a very large majority of all diathermia treatments are given for the sedative, absorptive and germicidal effects, the sedative technic will be discussed first. No matter whether the double cuff, plate or combination method is chosen, the preparation and application of the electrodes follow the same general lines. Each point will be gone over and at the end of the discussion on both technics a table will show the points of similarity and difference.

Fig. 11.—Enlargement of panel of moving picture film. Double cuff method of applying diathermia. The lower cuff on the calf is already on and bandaged and has one of the d'Arsonval circuit cords attached to it. The other flexible metal cuff (block tin 2 inches wide, long enough to reach around the thigh and lap on itself two or three inches) is being applied.

1. **Selection of Method.**—The selection of the method is governed by the pathology present and the anatomy and accessibility of the part to be treated. If a fibrosis of the knee is to be heated up preparatory to using forcible manipulation, etc., the double cuff will answer the requirements, one metal cuff around the fleshy part of thigh and the other on the calf, each one being several inches away from the joint so that even diffusion of current and heat will result. If a tuberculous spot on the internal condyle were to be treated then the double plate method would be used with a small plate on the internal side and a

much larger one on the outside. If an ankle is fibrosed instead of a knee, the combination cuff and water is better; a metal cuff on the calf and the foot in a pail containing about an inch of salt water with one electrode cord in the water, the other to the cuff. If a small pathologic area such as a short osteomyolitic spot in the shaft of the tibia is to be treated, the double plate method would be used on account of the possibility of more sharply localizing the heat in this particular spot. (For reasons see description of double plate method of localizing heat.) Diathermia through the head, chest, abdomen or hips usually requires the double plate method. If the tissues to be heated are very delicate in structure, such as the retina, or if a mild grade

Fig. 12.—Double plate method of applying diathermia. Two small flexible metal plates are about to be applied on opposite sides of the leg to treat a localized spot in the tibia. The metal plates are made long and narrow to prevent the possibility of their lapping around the limb far enough to short the current around instead of through the leg. They will be applied with their long axis parallel with the long axis of the leg and placed exactly opposite each other.

of heat would answer without producing an intense arterial hyperemia, then the indirect or modified diathermia such as described under "sharply localized high frequency" (technic described under "Treatment of Optic Neuritis") would be used.

Many variations in the method of administering diathermia will suggest themselves. Following are a few:

A man has endarteritis obliterans and the feet are so tender that you are unable to apply the combination cuff and water method you wish to use because he cannot keep the feet down

long enough to take even a short treatment. Place him upon a table face down with feet projecting beyond the end of the table. Apply one cuff to each calf and place a vessel containing salt solution on a box on a chair so that it comes up far enough to allow the toes of both feet to extend down into the salt water an inch or so and proceed to give the treatment. Keep the legs and feet separated so that no short circuits can occur from the feet or legs accidentally touching each other above the water level. It may not be possible to give full length or dosage treatments at first, but if it is persisted in daily the improvement that will result will be astonishing. Use ionizing doses of x-ray (5 milliampere minutes of a 5 "backup spark at 8" target-skin distance through one millimeter of aluminum) once a week in addition to the diathermia if it is desired to hasten resolution.

A man has a bad crush or dislocation of one of the phalangeal joints: Place a cuff upon the forearm and place the other circuit cord in a vessel having about one-half of one inch of salt solution in it. When ready to start the treatment have him place the tips of *all* of the fingers of that hand down into the water at right angles to it. When he can begin to feel the warmth in all his fingers have him gently raise one finger out of the water, concentrating the heat into the other fingers. Then have him raise another, and later another, etc., until all the heat has been concentrated into the injured finger. Have him hold this concentration on the injured finger until it begins to become unbearable and then lower the other fingers back into the water again. By using the other fingers as rheostats he can heat the injured finger much hotter than would be possible if the whole hand were to be heated. This is followed with the static wave to the injured joint, then massage and manipulation and the application of a light splint. Repeated daily, this treatment will demonstrate something new in shortening disability time, preventing loss of function, relieving pain, etc.

A patient has arthritis deformans affecting the fingers chiefly in the distal joint. Use a cuff upon each forearm and a vessel having about one-half inch salt water in the bottom of it. Bring forearms around until a line projecting down one will traverse the other up to the elbow; that is, have the hands so placed that

when the finger tips are placed in the water each little finger will be an equal distance from the other as compared to the distance between each third, second and first finger, and start the treatment. Keep the fingers of one hand from touching the fingers of the other hand above the water level as the short that will result when this takes place through the dry skin is very stinging in character. Ionize these joints with the x-ray as previously described, and use daily massage and manipulation on them. This is in addition to the elimination of focal infections, dietetic treatment, elimination of constipation, etc., usual in these cases.

2. **Choice of Technic—Sedative or Stimulative.**—The choice of technic is decided by the results desired. If a high degree of heat is desired, an intense hyperemia, an absorption of effusion or a softening of exudate or fibrosis, to relax muscular spasm, to sedate the pain of a neuralgia or neuritis or to help sterilize some chronic suppurative process such as osteomyelitis or empyema (always after drainage has been established) then the sedative technic should be used. If, on the other hand, it is desired to stimulate repair in a sterile area or to irritate and stir up an intense inflammatory reaction in some locality—a classical example would be nonunion in fracture—then the stimulative technic should be used.

3. **Electrode Material.**—The use of water-soaked electrodes in diathermia is always dangerous. Proper use of flexible metal electrodes is not. No matter what the material the water-soaked electrode is made from, the material itself is not the conductor of the current. *Dry* felt, asbestos composition, gauze, clay or other similar substances are not conductors. In fact, they are good insulators. Too many variable and changeable factors are working where heavy heat currents are delivered through a water-soaked electrode and this instability makes for uncertainty at all times and positive danger at others. In the first place it is difficult to saturate a felt or asbestos pad electrode evenly all the way through and the older they get the more difficult it becomes. With constant use they seem to become waterlogged in spots and deliver the current very unevenly. Gravity also af-

fects them. Take a new felt electrode, four inches wide and twenty inches long. Soak it until saturated. Stand it on end in a window for twenty-five or thirty minutes (the average time of a diathermia treatment) and examine it closely at the end of that time. Most of the water will have collected in the bottom two or three inches of the electrode. The current will go through the electrode at the place of least resistance. The result is that instead of putting a safe quantity of current through each of the eighty square inches of the electrode surface, the current has gradually concentrated until it is passing through about three inches of the lower part of the electrode and there is only 4×3 or 12 square inches of *active* electrode surface and the dosage calculated as being perfectly safe (and which would have been safe had the distribution remained even) has now concentrated to approximately one-seventh the original area. In other words, certain parts you thought were receiving heat have not been getting it and certain other parts you thought had been receiving a very safe dosage have been receiving several times as much current as you desired them to receive and a bad burn results.

As the upper part of the electrode drains and becomes a poor conductor, the resistance on that part of the electrode rises. Remember two basic rules that apply here. First, the heat generated in a given area varies as *the square* of the amperage passing through this area and, second, that the heat formed varies *as* the resistance. Part of the area is receiving *seven squared* or forty-nine times as much heat as was estimated, and the high resistance in the rest of the area, due to the dehydration of the electrode, has caused steam to form which has produced a blister. Thus a charring burn occurs at one end and a blister over the rest of the area. This is not theory, I have seen it occur. If this is not enough to deter you from using water-soaked electrodes then remember that bony parts pressing upon the center of such an electrode may dehydrate that part and cause a concentration of water (and current) around the edges or vice versa. Bedding, clothes or bandages syphon the water from the edges of the electrodes or, as we have seen, it may even escape through the stitch holes where the rubber cover had been stitched to the

body of the electrode, the large threads acting as wicks. If water-soaked electrodes must be used in the giving of diathermia treatments, care must be taken that they are *evenly saturated* over their whole area, that they are carefully applied and that too much weight is not placed upon them and that the rubber backing upon them extends at least one inch outside the edges of the electrode material itself on all sides and that the stitches and stitch holes have been rendered incapable of syphoning the water from the electrode into the bandage or bedding by covering the threads and holes with some wax, poured on hot, etc. In addition, the top edge of the electrode should be left in such a position that the nozzle of an ear and ulcer syringe or other rubber or glass syringe can be inserted and a small quantity of water added to that already in the body of the electrode at intervals during the treatment.

To avoid all this trouble and worry it is much better to use a flexible metal electrode. Twenty-two gauge Crooke's metal is the easiest and cheapest metal of the kind to obtain, but block tin, English limpet metal or a supply of old organ pipe metal is better. These flexible metals can be cut into proper shapes and sizes readily, are easily sterilized, and will last a long time before cracking or crumbling and, once properly applied, the distribution of current through them is a fixed factor. Twenty-two gauge is the best all round thickness. Thicker gauge electrodes are too stiff, hard to cut and mould to parts; and thinner gauge—say thirty-two gauge—ones are too thin, do not stay in contact so well, break too easily and do not distribute pressure so well. For instance, a wrinkle over a thin electrode would press the electrode into the flesh and possibly pull it away at some distal point. The firmer contact at the point of pressure might result in more current entering at this point and cause a blister. A thicker electrode would distribute this pressure and obviate the trouble. Long experience has caused us to adopt the twenty-two gauge as being the best all-round thickness.

4. **Proper Preparation of Electrodes and Skin.**—After the metal electrode has been cut to the desired shape, *all corners* should be rounded and the *sharp edges all around the electrode* scraped with a piece of sharp edged glass, a knife or the edge of a scis-

sors blade. Current under high pressure (voltage), and especially high frequency, tends to try to escape from a charged surface by the corners or sharp edges. Assuming that the electrodes have been selected and properly made, the next step is to moisten both the electrodes and the skin where they are to be placed. For the same reason that a barber uses lather upon the face to soften the beard instead of using plain water, we use a soapy lather upon the surface of the electrode and upon the skin. Dry skin has a very high resistance to the passage of currents of electricity and were the dry metal electrodes applied to the dry skin and the current turned on, a smart prickling and burning would ensue. This, in addition to the pain caused, which is quite intense if heavy currents are so used, stirs up the reflexes and sets them in action to neutralize the sudden introduction of heat in a painful manner. The reason for the pain is that, while the skin as a whole is dry, there are small sweat ducts leading down into the skin through the horny layers and the current condenses and enters through these ducts because the salt solution in them offers an easier path than the dry skin. Any electrical current will burn and sting if concentrated to a fine point. Lower the resistance of the skin by lathering it and removing much of the horny layer resistance and this concentration does not take place and the treatment may be started painlessly and even pleasantly. The only sensation a patient receiving a properly given diathermia treatment should feel should be one of grateful, soothing warmth. He should feel no faradic sensation whatever. If he does, something is wrong, somewhere.

5. **Proper Application of Electrodes.**—If the cuff method is being used the metal cuff should extend all the way around the limb and lap over on the ends. Remember that the part of a cuff which laps over the other end is *inactive*. That is, in calculating dosage, you are only to figure as *active* that part of the cuff which is actually touching the skin. If you have a metal cuff eighteen inches long and two inches wide and upon applying it find that it laps over four inches, then you do not calculate that you have 18 × 2 or 36 square inches of electrode surface, but 14 × 2 or 28 square inches of electrode surface. The

cuff should be applied so that it is evenly in contact all the way around the limb and not in contact on one edge and cocked up off the skin on the other. Any excess lap that does not fall *upon* the other end must fall upon the skin *outside* the area included between the two cuffs and not inside this area.. The reason for this is obvious; if each cuff lapped several inches and each lapped end were allowed to fall *inside* then practically all the current would follow the metal to the end and then through the tissues to the other end of the other cuff, thus cutting off several inches of resistance on each end. It makes no difference how much overlap projects onto the skin *outside* the area desired to be heated but it would upset all calculations if allowed to fall upon the skin between the two cuffs.

If the double plate method is to be used, the same general rules apply as to the preparation of electrodes and skin. Care must be taken that the planes of the two metal plates are as nearly parallel as it is possible to make them. They should never be made large enough so that they fold around a limb thus bringing the outside edges of the opposite electrodes much nearer to each other than the centers are. In this case practically all the current would follow the metal (which has practically *no* resistance) to the edges which are separated by several inches less of tissues than the centers of the electrodes and consequently the very much lessened distance between the edges, offering much less resistance than the thicker tissues between the centers of the electrodes would offer, would furnish the path of least resistance and so receive practically all the current. It is better to make plates to be used upon opposite sides of a limb longer and narrower than shorter and wider. A slight amount of curving does no harm but care should be taken not to allow the metal to curve around the limb enough to materially decrease the resistance between the edges as compared to the resistance between centers.

I have seen it urged in print that the use of metal cuffs be condemned because of the danger of a sharp corner of the electrode coming into contact with the skin and producing a burn; that the double cuff method was dangerous because it produced "edge effects," etc. The most charitable thing that can be said

of those making such criticisms is that they, by their very criticisms, display such an ignorance of the subject as to make their criticisms ridiculous. No physician who knows *anything* of the tendency of high frequency currents to *leave a charged body* (electrode) *by sharp edges or corners* in preference to flat or rounded surfaces is going to apply any such sharp cornered high frequency electrode to a patient or advise any one else to do so. I have always made it a particular point to say that all metal electrodes for use in diathermia should have *all* corners rounded and *all* edges scraped or rounded until they resemble the contour of an automobile tire.

As to the production of "edge effects," we had numbers of aides who worked months and years in the largest and busiest diathermia section ever established (so far as we can ascertain) who never saw an "edge effect" during their whole service in our clinic and who will ask you what you mean if you inquire whether they ever secured any such effects. We used all methods of applying diathermia, but the double, metal cuff method was (for many reasons) used more than any other single method. *Any* method of using diathermia will produce burns or edge effects if too much current or wrongly shaped or incorrectly placed electrodes are used, and water-soaked electrodes, similarly used, will give burns much quicker and oftener than metal ones will. Edge effects are possible with any kind of electrode unless properly placed and used; and incorrectly made, placed or used water-soaked electrodes are still more dangerous than flexible metal ones. The main purpose in using cuffs instead of plates is to include more area in the heat zone and if the cuffs are to be crowded to within five or six inches of each other, then the milliamperage had better be cut down and the double plate method used; for, certainly, dose for dose and distance for distance, plates are more dangerous than cuffs.

The further objection is often made that the current travels almost entirely by the blood vessels and therefore the flexor surfaces heat up much faster than the extensor, etc. As proof is cited the admitted fact that thermometers placed upon the flexor surface will always register higher than those placed upon extensor surfaces. What is the law of resistance? Is it not

that the heat formed varies *as* the resistance? What becomes of all the tremendous amount of heat generated in the tissues every moment during a diathermia treatment? *Certainly* the flexor surfaces show a few degrees higher temperature, for all the heat of the whole area is being gathered up and removed or carried via the vessels which always lie in the more protected flexor sides of joints. The greater heat of the blood is not due to its carrying *most* of the *current,* but is due to its carrying *most* of the *heat* which it has abstracted from the surrounding tissues exactly as the circulating cooler water abstracts heat from the hotter automobile engine. The speed of these discharges (traveling at the speed of light) prevents them from wandering around hunting an easy path. In addition to the positive speed of projection they have the attraction of the oppositely charged electrode to attract them as this is an oscillatory discharge and the instant one electrode is positive the other is negative and the next instant this is reversed. The blood actually heats *less* than any other tissue from the passage of the current itself as it has less resistance than any of the other tissues.

As to the criticism that the double cuff method *is not efficient:* When it comes down to the question of the efficiency of a method, the verdict must be left to the judgment of those having the most experience and who have correctly tried the method oftenest in more different kinds of cases, etc. Statistics from men whose criticism shows upon its face that they have tried it incorrectly, if at all, should be ruled out. But even allowing such statistics to stand, we contend that our successful use of the method in almost unheard of numbers of treatments entitles us to make the statement that, properly used, the *double cuff method is efficient,* and to ask for more proof and stronger proof as to its inefficiency than has been offered to date before we will yield the argument.

6. **Use of Elastic Bandages.**—The first thing to take place upon the starting of a diathermia treatment is an arterial hyperemia the degree of which is subject to very delicate control. This causes a swelling of the part varying with the degree of hyperemia induced but the increase in size of the part always

follows. On most parts of the body where plates or cuffs are used bandages are necessary to hold them in even contact with the skin. If cotton, gauze or other nonelastic bandage is used, this swelling causes the bandage to act as a tourniquet, causing pain and rapidly converting the very desirable arterial hyperemia into a very much less efficient venous hyperemia and later, if a high degree of heat is applied to a circular part such as the thigh or upper arm, converting it into an actual ischemia. The chances are that before this stage has been reached the patient will demand relief from the constriction and the treatment will have to be interrupted several times to loosen up bandages. Either way it is bad technic and will defeat the securing of maximum good results from the treatment. To avoid the conversion of an arterial into a venous hyperemia or even into an ischemia or to obviate interruptions of the treatment to loosen bandages which converts a sedative into a stimulant process, we adopted the use of woven elastic bandages.

These bandages are made of rubber and cotton and will last for several months under constant usage before losing their elasticity. I have adopted the three inch width as being the best all-round size. If they are too tightly applied they have little or no advantage over the nonelastic type. They should be stretched only just enough to keep out the wrinkles which would appear if they were applied very loosely. They will seem to be too loose when the treatment starts but if they are applied just barely tight enough to keep the cuffs or plates in contact until the current starts, the expansion of the part will make them snug in a few moments and they will have elasticity enough to give before the expansion without cutting down into the flesh. Do not use too many thicknesses or turns or they will not be elastic enough. The loose ends can be pinned, stuck into place with a short strip of adhesive or, as we usually do it, a turn of the bandage pulled up by its elasticity and two or three inches of the loose end tucked snugly under the turn. When it is released the end will be held firmly enough to hold it during the treatment. This is a time saver where large numbers of treatments are being given.

Sometimes, as in chest treatments, one electrode can be placed

underneath the part or body and the other held in place by laying upon it a partially filled, flexible sand bag. This should not be heavy enough to cause discomfort nor should the bag be filled tight enough to cause it to roll off the electrode if the part is moved a little. A good way to keep sand or shot bags from becoming lumpy is to make the bag and then run rows of stitches from the bottom to the top at intervals of an inch or more apart and fill each long pocket only partly full of sand. This will adapt itself to almost any shape and will hold its place much better than if filled too full or if all the sand is allowed to collect in one corner of the sack.

I have seen the practice advocated of placing *permanent* diathermia electrodes under the plaster of paris cast when the cast was being applied so that diathermia might be given to the limb encased in the rigid cast. This is exceedingly bad practice and should *never* be done. No limb encased in a *rigid* cast or splint or even in *rigid* bandages should be diathermized while *in such rigid support.* I know of almost nothing in the gamut of disease or disability which comes nearer to destroying a limb or the effects of which are harder to remove than those of ischemic paralysis and if a real diathermia treatment should be given to a confined limb there is grave danger of producing that condition. If diathermia of a limb to be encased in plaster is to be done, then the cast should be split up the sides. When the time to give the treatment comes, remove all rigid, nonelastic bandage from around the cast, substitute a few turns of woven-elastic bandage and proceed to give the treatment. Expansion is thus allowed to be expansion and not compelled to become compression. When the treatment is over and the limb has resumed approximately normal size, the elastic bandages should be removed and the nonelastic bandages replaced. It is not necessary to remove the limb from the cast but if there is no objection the top half of the cast may be removed during the treatment and replaced afterwards.

By the same token the use of rigid frames to hold diathermia electrodes on soft tissues during treatments is taboo. Some of these appliances *are* ingenuous but, also, they *are* rigid and most of them soon become unutterably filthy.

7. **Beginning Treatment Properly.**—In using the sedative technic the principle is to start the treatment very gently, deliver a comparatively heavy heat for the full time of the treatment, after the maximum is reached, without interruptions and to terminate the treatment gently. To begin the sedative treatment properly, see that all adjustments on the machine are set at the lowest notch and that the hot wire milliammeter needle rests exactly over the zero mark on the calibrated scale. This needle can only be set accurately when the meter is cold—that is, when it has not been used for a few minutes. If it has just been used the needle may not fall clear back to zero until the wire cools. All good meters have one or more means of making this adjustment. Most of them have a slot at the bottom of the meter with a metal pin projecting through it. This pin is fastened to the dial plate so that the plate can be rotated to right or left, as the case may be, enough to bring the zero mark under the needle or indicating hand. In addition, some meters have a slotted screw head, sunk below the shell of the meter, level with the shell or even standing above it. This adjusting screw may be located at the top, side or bottom of the meter. When it is present, a light touch of the screw driver turning it to right or left will raise or lower the indicator hand by increasing or diminishing the tension on the spring which holds the hand to zero. It is not advisable to bend the indicator hand itself and the interior adjustments of the meter, being very delicate, should never be tampered with unless by some one familiar with their construction and the function of the various parts. Having the meter correctly adjusted and all the controls on the machine set at the lowest adjustment (that is, on the button where the least current will be used) see that the spark gap is closed.

Never start a sedative treatment with the spark gap open and never change any adjustments on the machine while the spark gap is *open* and current passing. It does no harm to the transformer to short circuit it for a few moments by closing the spark gap while making these adjustments, then gradually opening it again, but the machine should not be allowed to run *very long with the spark gap closed* as it will cause the transformer to heat up rapidly and if much current were entering the transformer

would burn it out in a very few minutes. When all the adjustments on the machine are set on low and the spark gap closed, connect up the cords from the patient's electrodes to the d'Arsonval terminals. Look everything over (it takes only a glance, and this last look habit will often save both the physician and the patient some unpleasant moments) and then, being sure that everything is correct, close the main switch (the "on and off" switch or the knife switch which admits current to the transformer). As soon as this switch is closed, open up the spark gap a small amount and allow the reduced current to pass for from thirty to sixty seconds. The meter will probably register from one hundred to three or four hundred milliamperes depending on the size of the machine, type of spark gap, resistance between electrodes, etc. After this small amount of current has passed this length of time, gently close the spark gap, move the main control rheostat up a button or so and again gently open up the spark gap. The meter needle will now register the passage of more current than before and the patient will probably feel the heat. If the machine is of the fixed condenser type, repeating this procedure is all that is necessary to raise the meter reading to the desired point. If the machine is of the variable condenser type new sections of the condenser may be cut in while the spark gap is closed. The switch for cutting in more condenser surface is usually labelled "frequency changer" or "frequency selector." It should take about four or five minutes to run the meter reading from zero up to the desired reading in this sedative technic.

8. **Timing the Treatment.**—The duration of the treatment will depend, to a large extent, upon the primary indication. If it is being given to relieve a neuralgia or prepare parts for massage, static, etc., then twenty minutes is usually sufficient. This allows four or five minutes to reach the maximum heat and then allows this maximum to act for fifteen minutes. If the treatment is being given through a pus bearing area, such as empyema or osteomyelitis, then the time can be lengthened to forty-five minutes, an hour or even longer with benefit. Long experience before the war and a tremendous amount of this work in the reconstruction hospitals has only served to confirm me in my

opinion that, where diathermia is being used for the sedative, absorptive and sterilizing effects, the best results cannot possibly be obtained with any regularity where less than twenty minute treatments are administered.

9. **Proper Use of Spark Gap and Condenser.**—The spark gap is supposed to be a *variable* resistance placed in the high tension circuit of a high frequency machine for the purpose of controlling the voltage at which the condenser charges and discharges. A clean spark gap *is* a variable resistance but a dirty one *is not.* A dirty gap is a fixed, high resistance and delicate work cannot be done with it. It takes as much pressure to force current through a layer of oxide on the gap tips when they are closely

Fig. 13.—Enlargement from motion picture panel showing operation of cleaning the open type of gap. This type of gap in addition to being simple to clean needs cleaning very much less often than the closed type. A piece of fine sand paper is folded back upon itself so that the cutting surface is on the outside, the points are separated by turning the vertical adjustment knob, the sandpaper slipped between the tungsten pointed tips, the gap closed down until the paper will just slip without tearing and the sandpaper slid back and forth a few times. This method of cleaning keeps the faces of the points parallel—a thing absolutely necessary if the gap is to give the best service. When all points have been cleaned, the dust is blown off the gap and it is ready for service.

approximated as it does to force the current to jump the air gap between clean surfaces when they are separated. Consequently a dirty gap acts when almost closed exactly as would a clean one when wide open. The open type of spark gap is easily cleaned if it is in an accessible position but the closed type is complicated, hard to clean and hard to reassemble and adjust. In fact there is no way you can adjust it except by putting in new points or by thinning down the insulation be-

tween sections. It is a factory job or a job for an expert electrician to clean or repair them. The closed gap is not flexible enough and will not stay in order. Due to formation and condensation of gases, moisture, etc., the insulation frequently punctures and must be replaced. The points cannot be seen and adjustments must be made "by guess and by gosh." We have two extra gaps for each machine using this type of gap and an expert to keep them clean and in repair and even then

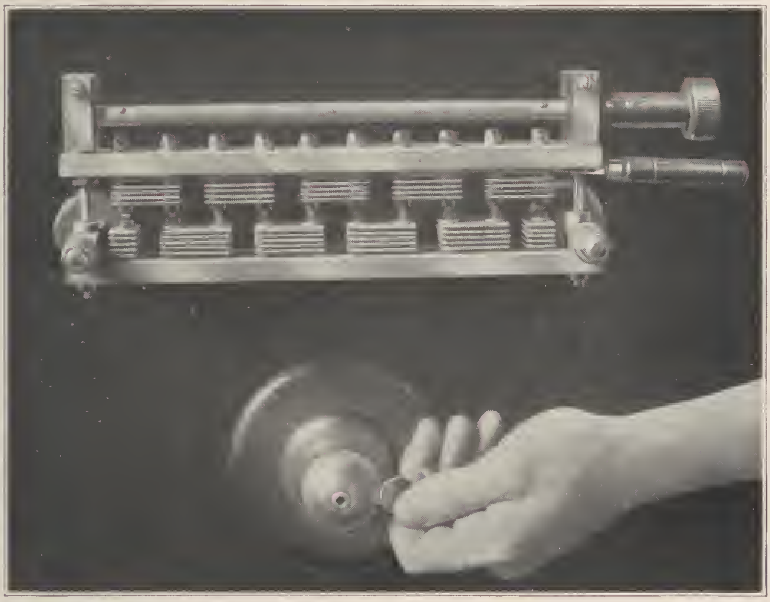

Fig. 14.—A comparison of Figs. 14 and 15 will show the range of control with the open type of gap having both a vertical adjustment for varying the distance between points and a horizontal sliding rod for selecting the number of points to be used. In Fig. 14 only one pair of points are in use and they have been closed down until current is just barely passing. They can be set to give even less than is shown on the photo but it would not reproduce. They can be set (when properly adjusted) to give such a fine current from the Tesla or Oudin terminal that it can only be seen as a faint effluve in a dark room.

the machines are very seldom in shape to give good service, and when in shape will not stay that way very long. These gaps will stay in order a little longer and be a little more steady in operation if a current of air is constantly pumped through them, but even then they are inferior to the open type. If the open type has adequate air circulation and, especially, if it has a

double range of adjustments (both a way of varying the number of points in use and a way of varying the distance between these points) it is so much more steady in operation, more flexible and easy to clean and demands so very much less cleaning due to its rapid cooling that there is little room for comparison.

As an illustration of the two types of gaps: the urethral non-vacuum electrode cannot be used safely from the closed type of gap. The variation in heat from the opening of one more section when the thermometer shows a little less than the desired heat will run the temperature up beyond the blister point. The

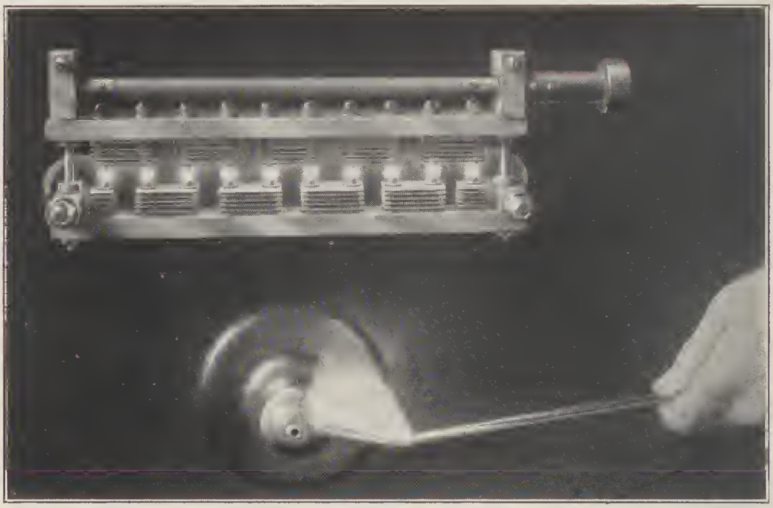

Fig. 15.—Shows the gap wide open and all the points active. Any possible point in between these two extremes can be reached by varying the number of active points and the distance between them.

thermometer will fluctuate between wide limits even if the closed gap be set and left running on a given point. With the open type and a double range of adjustments, the thermometer can be run up to any point desired in steps of less than half a degree each and will stand at this selected point for an hour (under actual tests) with a fluctuation of not more than half a degree during this time. This is one of the most exacting tests of spark gap efficiency as to flexibility and stability that can be made.

The spark gap should never be opened or closed abruptly

while giving a *sedative* diathermia treatment. It should never be opened to a point where the steady hiss of the current passing over the gap is replaced by a sputtering sound and the needle on the meter wavers up and down. There is a point on each set of the gaps and controls where the maximum *smooth* heat occurs and this can only be found by close observation. As a general rule it is better, in securing the degree of heat desired, to use more condenser surface and not too much spark gap than to try to crowd the meter reading up by opening up the spark gap beyond the critical point. As long as the hiss of the spark gap is steady and uninterrupted and as long as the meter indicating hand advances *uniformly* as the gap is opened then you probably are not using too much gap, but if the indicating hand does not advance, or if it advances, falls back a little, catches and advances again or if the hissing sound changes to an intermitting sputter then too much gap is being crowded on. Often when this point is reached if the gap be closed a trifle the meter hand will at once advance two or three hundred milliamperes.

The condenser can be any one of several types: Leyden jars, glass plates, mica or, as in some cheaply constructed machines, even waxed paper. Its function is to act as a frequency step-up transformer and the method by which it does this has been described in the chapter on "High Frequency—General Considerations."

10. **Terminating Treatment Properly.**—In using the sedative technic it is only necessary to avoid brusqueness in terminating the treatment. It is not necessary to take nearly so much time in lowering the meter to zero as it is in raising it from zero to the maximum. About a minute or a minute and a half should suffice to reduce the current to zero. Simply reverse the steps by which the current was raised. If the control rheostat has been advanced several buttons it may be lowered two or three buttons at a time, of course not forgetting to close the spark gap just prior to making the change in the setting and to open it immediately afterward and allow the reduced current to flow a quarter or half a minute before still further reducing it.

11. **Calculating Dosage.**—A good milliammeter set at zero is required until after an operator has become experienced in the

use of diathermia and has used his particular outfit until he knows just what it will deliver on a given set. *If* he is perfectly sure that the patient has no anesthetic areas, hysterical or otherwise, then he may use the tolerance of the patient as a guide. Again, we have seen meters, changed from one machine to another, both being used on the second machine, through a fixed resistance, spark gap, etc., and all factors exactly the same, vary in their readings as much as one hundred per cent. Again, the quality of the current has an effect on the amount of heat produced. Five hundred milliamperes on one machine and meter may heat a part up as much as or more than a thousand milliamperes from another machine delivered through exactly the same electrodes and resistance. Whether this difference in effect from the same meter reading on different machines is due to damping out of oscillations, different kinds of spark gaps, meter variation, or what not, it is a fact that it does occur and for that reason no hard and fast rule can be laid down as to the safety limit or density of current dosage rules. The rule in our clinic (which rule takes into consideration this variance) is that no Aide will exceed a dosage of one thousand milliamperes (1000 ma.) on an electrode surface of sixteen square inches (16 sq. in.), unless instructed to do so. This would be an electrode four inches square or two inches wide by eight inches in length or approximately five inches long by three wide or ten inches long by one and a half inches wide, etc. Where electrodes are properly applied we have never seen a blister, let alone a burn, result from this dosage. Personally, we very often exceed this dosage density but as we have nonmedical technicians (very finely trained, however) giving the treatments it was necessary to set a limit. We have no intention of saying that this is the maximum safe limit; only that it *is* a safe limit.

12. **Basic Laws that Apply.**—1. Density of dosage. The density varies inversely as the area. This means simply that in a bipolar application if two unequal sized electrodes are being used the smaller one is the *active* electrode and dosage calculations must be made with its area as a base and not the area of the larger electrode. For instance, one electrode ten inches square is being used and the other one is five inches square. The first

eleetrode has one hundred square inehes of area and the second has twenty-five square inches. The first has four times the area of the second. One thousand milliamperes of diathermia current is being given. If the density varied *as the area*, then the density of eurrent would be four times as great on the larger electrode as on the smaller, but the reverse is true. Obviously eaeh eleetrode is earrying the same amount of current (1000 ma.) and as one hundred square inches are earrying one thousand milliamperes, then eaeh square ineh is carrying ten milliamperes. On the seeond eleetrode, twenty-five square inches are earrying one thousand milliamperes, therefore eaeh square ineh is carrying forty milliamperes or just four times as mueh as each square ineh on the larger eleetrode. The term density of current means the number of eleetrical units passing through a given unit of area. Hence the rule that the density of eurrent varies *inversely as the area.*

2. The amount of heat formed in eonductors or tissues varies *as the square* of the amperage. This means that when you have donbled the meter reading you have not doubled the amount of heat being formed in the tissnes between the eleetrodes but having doubled the amperage, the square of two being four, you have quadrupled the amount of heat being formed. If you triple the meter reading, the square of three being nine, you are now having nine times as mueh heat formed as was being formed before you inereased the eurrent. If you increase the meter reading six hundred per cent or, say, from three hundred milliamperes to eighteen hundred milliamperes, then the tissues between the eleetrodes are reeeiving six squared or thirty-six times as mueh heat, ete.

3. The heat formed in a given part from the passage of a given amount of current though it varies as the resistanee, that is, if current is compelled on aeeount of pressure (voltage) or speed of oscillation to travel in straight lines through tissues of varying degrees of resistance then the tissues having the greatest resistanee will generate the most heat. After a diathermia treatment is started, the part should be covered, preferably with rubber or oil cloth and the longer after the treatment that the part ean be kept covered and quiet the longer will the heat and

hyperemia persist in the part. The heat in deep or well protected parts, especially bone where the circulation is not such a factor in rapid cooling, will persist for some hours after the cessation of the treatment.

13. **Effects Produced in Tissues by Each Technic.**—The primary effect from the use of larger amperage diathermia currents is the formation of quantities of heat. The way this heat is formed—by virtue of the resistance of the tissues themselves—*in the very tissues we wish to have the heat* makes it certain that the heat is delivered exactly where we want it. The further fact that bone, callus and scar tissue offer a high resistance insures their receiving more heat than the surrounding tissues although these surrounding tissues can be heated to a high degree. As a direct result of this conversive heat, occurs an intense arterial hyperemia when the sedative technic is used and a mild arterial hyperemia when the stimulative technic is used. This hyperemia causes increased metabolism in the part by dilating all blood vessels, opening up lymph channels, activating phagocytes as well as increasing their numbers in the area, activates the enzymes and increases osmotic processes. The traveling through the part of such inconceivably rapid oscillations produces a vibratory effect upon each molecule, atom and electron and as the difference between a malfunctioning or nonfunctioning atom and a perfectly active one may be so slight as the gain or loss of a single electron and, as we know nature's penchant for taking up and using anything she may need when it is or can be made available, the passage of a high speed stream of electrons or oscillations through abnormal tissues results in a general resumption of activity by many cells that have been, so to speak, lying down on the job. Be the exact scientific explanation what it may, it is a clinical fact that this very thing does occur with regularity when diathermia is used properly and according to indications.

The sedative and relaxing effects of heat are in evidence from the first treatment. Stasis is broken up and insoluble deposits made wholly or partly soluble. The inhibition of bacterial growth by the high temperature produced is inevitable and the aid that diathermia has rendered in clearing up many inoperable

cases of empyema and osteomyelitis is well known to every experienced user of the proper technic and is acknowledged by the surgeons referring the cases for treatment. In fact, in our hands, it has been so uniformly valuable in these conditions that we are quite prepared to make a statement that will be vigorously disputed by those who have not seen it properly used in these conditions and that is that any patient of either kind that is allowed to die without this treatment having been used certainly has not had everything done for him that could have been done. Criticism of this statement is entitled to respect only if it comes from one who is qualified to make it by experience in the proper use of the method, and I have never heard a breath of criticism from any such man.

The effects of the stimulative technic are described by the title. It is used only to stir up a reaction and stimulate repair in sluggish but sterile areas. Here no high degree of heat is formed, the treatment is short and snappy and the object to irritate the tissues and provoke reflex action. We have repeatedly seen the cramps following the application of this technic become so painful that an anodyne was required to relieve, but as this was exactly the effect we were trying for we did not consider the treatment a failure. These cramps may not appear in some cases for many hours—as long as eighteen hours—and in other cases may not be severe enough to compel notice but if the technic is applied carefully they will always result, in some degree at least.

14. **Indications and Contraindications.**—The indications for the sedative technic are so many that to list all of them would cause me to break one of my rules never to write a list of diseases or pathologic conditions and then prescribe for them. One of the greatest indications (from the patient's standpoint) is to relieve pain. Any one using diathermia over a wide range of conditions is immediately struck by the number of patients who rejoice in the relief of pain. It is indicated in any *beginning* "itis" and in many chronic ones. It is indicated where it is desired to overcome an irritable, tetanic contraction of muscle fibers such as follows severance of a peripheral nerve or a traumatic "charleyhorse." It is indicated to produce an intense *arterial*

hyperemia wherever this condition would be beneficial or where an atrophy is to be arrested, as in paralysis agitans. I would not attempt to handle the worst cases of fibrosed joints without its aid. Here its use not only softens the fibrosis making it safer to use more force but makes the using of such force much less painful and takes care of the absorption of traumatic exudates following such procedures instead of having them *in situ* to reorganize or to interfere with future treatments. A fracture will respond to proper manipulation in splinting with greater ease due to the relaxation of muscular spasm, the pain incident thereto will be lessened and repair will proceed much faster if even a single diathermia treatment precedes the operation. Osteoporosis, taken at any time before abscess formation, has never failed to clear up under this remedy in our hands. The relief following the first treatment in an acute cystitis, prostatitis, epididymitis or orchitis will be so great that all other procedures will seem still more inadequate than they really are. Pus *with* drainage is a good indication. Endocarditis, pericarditis and myocarditis are all good indications as is angina pectoris. The pain of the latter is almost instantly relieved and the attacks cut down both in frequency and severity. Repeatedly have we seen "pipe stem" arteries (not in aged persons) plainly shown upon an x-ray plate, drop out of the picture after an extended course of diathermia. The use of diathermia in beginning pneumonias is followed by such sudden relief of symptoms and changes in the clinical picture presented that about the only criticism given by physicians seeing it properly used in the early stages is that the cases were not typical pneumonia cases anyhow. They are right. The cases were not typical pneumonia cases. The difficulty in having a typical pneumonia develop under early diathermia is so great that we have never seen it accomplished.

The idea of treating pneumonia by means of diathermia is not a new one. In the fall and winter of 1909-10 I treated four cases with a portable outfit and possibly others may have used it prior to that time. The treatment in those days did not "take." No one could secure average good results with the best technic known then and the method was soon discredited. In subsequent seasons I left off the use of diathermia on these

cases due to their tendency to "blow up" under the treatment. At the same time I gave it as my opinion that diathermia was contraindicated in acute arthritis, neuritis, etc., and this conclusion was based upon results secured by the use of every technic tried by myself or advocated by others up to that time. I knew that it ought to give good results but it did not.

When eighteen months of laboratory research showed me why bad results occurred when all reason led me to expect good re-

Fig. 16.—A corner of the diathermia section showing six diathermia treatments being administered and two autocondensation stations in the far corner of the room. Every type and make of diathermia appliance received thorough tryouts in this clinic.

sults, I built up a *sedative* condenser discharge technic which obviated every fault of the older technics and bore no resemblance to them. I separated diathermia technic into two parts —sedative and stimulative instead of *all* stimulative as it had been—and found that the new sedative technic was infinitely more valuable than the stimulant because of the vastly increased range of indications that could be met by its use in conditions

where the use of the stimulant technic gave no results or actually made things worse. (Over 90 per cent of diathermia indications call for the use of the sedative technic.) What a startlingly sudden reversal of opinion I had to make when I tried the new technic upon the same classes of cases. Conversive heat in the form of diathermia is now my first thought and principal reliance in the very conditions that I formerly had thought contraindicated its use. The reversal of the order forbidding the use of diathermia in certain classes of cases in 1918-19 following a large and very carefully checked demonstration of the positive merits of sedative diathermia was the first big scale proof of the great efficiency of the new sedative technic and other demonstrations have followed so fast as to beggar description. The proof is now so overwhelming that it cannot successfully be controverted.

When a brilliantly successful result follows the use of some new therapeutic procedure, it may *very well be* an accident; but when the same result can be duplicated with mathematical precision over a period of years, no man who cares to study the subject with an unprejudiced mind is going to call it accidental, especially when every physical reason for the steps in the technic and the biophysical reactions that ensue are explained. I do not know who first penned that vitriolic line, "They who can, do; they who cannot, criticize," but I am perfectly sure that he was comparing positive therapists to negative therapists. Probably some poor, heckled physiotherapist so far forgot himself that he blurted out the truth.

So far as I know, only one series of pneumonia cases treated with this sedative technic has been formally reported—a series of ten cases treated at the U. S. P. H. S. Hospital at Stapleton, by my coworker in the service, Harry Eaton Stewart, M. D. (This paper was read at the thirty-second annual meeting of the American Electrotherapeutic Assn., N. Y., Sept. 19, 1922, and published in the October, 1922, issue of the *American Journal of Electrotherapeutics and Radiology*.) I shall quote some of his conclusions: "When we have had many more cases to report on, we hope to be able to make a more definite statement, but this much we do know, that in *every single case* and in almost every single *treatment* the temporary effect upon the patient

was remarkable. Cyanosis disappeared. The expiratory grunt when present was markedly lessened or stopped entirely. Respirations were less labored and the patient received from two to four hours of very marked relief, in many cases obtaining sound sleep, etc." Among the other discussions of this paper I remarked as follows: "We have all had the experience of treating a series of pneumonia cases with diathermia and of having had the internist criticize the series by saying that none

Fig. 17.—Another corner of the diathermia section showing six diathermia treatments and one autocondensation at the far end. Four different kinds of diathermia treatments are shown here; the cuff and salt water method, the double cuff method, the double plate method and one indirect diathermia.

of the cases were typical cases anyhow. I have never seen a 'typical' case follow the early application of diathermia. I have come to believe that such a sequence is impossible. The possession of a means of applying conversive heat in the form of sedative diathermia gives one a means of applying a form of heat so much more efficient than poultices, mud jackets, etc., that it is a source of wonder to me why doctors do not study up on

the physics and upon the relative efficiency of the various forms of heat. The possession of such a means is of inestimable value to any one treating diseased conditions in general and pneumonia in particular.'' Dr. A. B. Hirsh, who was with us as an assistant at the Fox Hills Hospital studied diathermia as it was being used there and wrote two papers upon two of its many uses. His cases were not selected from the records but were cases that were treated while he was there. One of these papers was ''Diathermia in Some Bone Lesions'' which was published in the *Surgery, Gynecology and Obstetrics,* Jan., 1921. The other was ''Diathermia an Aid in Empyema'' which was published in the *Medical Record,* Dec. 18, 1920. (Incidentally I have a moving picture of the empyema case with thirteen osteomyelitis sinuses, whose history is detailed by Dr. Hirsh, receiving his diathermia treatment.)

Neuralgias are, as a rule, promptly relieved. Endarteritis obliterans, even where the feet are so tender that they cannot be handled or kept hanging down when attempt is made to treat them by the cuff and water method, can be arrested, circulation improved and all clinical symptoms bettered by following the method described on page 71. It may be impossible to give full length or strength treatments at first, but tolerance is gradually established. If the process has reached above the knees, then each leg should be treated separately by a cuff upon the thigh and a foot in salt water. Catarrhal jaundice sometimes responds in a surprising manner. Visible clearing up has been noticed as early as seventy-two hours after the first treatment.

My results in the use of diathermia, *followed by the static wave* through the kidneys in chronic Bright's disease (not too far advanced) have been consistent enough and good enough that I believe that these patients should always be given this sequence in addition to their medicinal and dietetic treatment. Whether the clearing up of albumin and casts in the urine which often results after a few weeks or months of this treatment will be permanent cannot be stated positively as I have not had opportunity enough to trace up our cases over a sufficient length of time to say that this will occur, but I can state that some of them will clear up and remain clear for some months or years. Even

this benefit is worth the trouble it takes to gain it. These cases are treated daily for some weeks, then three times weekly, then twice weekly, and are advised to report for examination frequently for the first year and at intervals of a few months for years thereafter. Upon the slightest sign of a lighting up of the process the sequence is repeated. No doubt anyone who has once had chronic nephritis will always remain liable to a flare-up upon sufficient exposure or irritation and they should be warned against overexposure or dietetic excesses. This has occurred in three of my cases but the recurrence was caused by gross overexposure and was controlled in the same manner as was the condition when first started upon treatment.

I have not given a complete list of indications by any means but have given enough to show the wide range of conditions that can be benefited by the proper use of this extremely valuable remedy.

Contraindications.—There are only two major contraindications for sedative diathermia. These two are, a liability to start a hemorrhage and a liability to cause absorption into the blood or lymphatics of dangerous quantities of toxic material, such as bacteria, pus, enterotoxines, etc. All other contraindications are more or less directly derived from these two. No remedy will so quickly relieve the intensely painful cellulitis that sometimes follows tonsillectomy as sedative diathermia through a couple of medium to small sized plates over the painful, brawny area around the stumps but, unless the surgeon himself advises it, it is best not to do it. I have used it the next day after the operation in several cases without any bleeding to speak of resulting, but on one case where it was used upon the advice of the surgeon—he assuming all responsibility—the hemorrhage which followed was quite profuse and worried the surgeon for several hours before it was finally controlled. The danger lessens rapidly after forty-eight hours and is almost nil after three or four full days. Empyema is one of the best indications *after drainage* has been established, but if diathermia is applied before the pus has been evacuated, absorption of bacteria and pus is almost certain to result with the usual bacteremia sequence or the formation of metastatic abscesses. The operator will have to use his knowl-

edge of the effects produced in the locality where he is using diathermia and his knowledge of the physiologic distribution of blood to that and related organs to determine whether the local effects will disturb such distribution and, if so, more than counterbalance such good effects as might occur from its application at that particular time. Sometimes these conditions change very rapidly. Active digestion might contraindicate its use in a cystitis for a couple of hours after the meal and then cease to be a factor until after the next meal, etc.

Stimulative Technic.—The stimulative technic differs from the sedative in several particulars. Where this technic is used, it is desired to stir up a local irritation or tissue reaction. Sedative, absorptive or germicidal effects are not wanted. Therefore instead of the very gradual beginning, the high degree of heat, the long application, the careful use of a clean spark gap and the gradual shutting off of the current such as is used in the sedative technic the following procedure is carried out:

Both technics are the same up to the point where the current is to be turned on. With the stimulative technic, the controls are set about where experience has shown that they would have to be set to secure the dosage desired, except that the spark is closed. Close the main switch and immediately, and with one quick turn of the wrist if possible, open the spark gap to the full extent that will allow the current to pass. Let the current pass for four, five, six, or seven minutes and cut it off abruptly. About one minute before the close of the treatment open the gap still further until the peculiar, intermittent hiss and sputter of the gap indicates that you are interrupting the current, and allow the current to pass in this manner for a full minute, and then—spark gap wide open—pull the main switch. (Cut off current going into machine.) This interrupted high tension current is very stimulating. As only a moderate arterial hyperemia and not enough heat to cause absorption is desired, only about one-fifth to one-third the amount of current is used that would be used for a sedative treatment. If, with a given set of electrodes and the sedative technic, we figure or estimate that fifteen hundred milliamperes of current would be used, then

with the same electrodes, application, etc., to secure stimulating effects from three to five hundred milliamperes will be required.

If the spark gap is of such a type that it will not admit of being opened to a point where the current is almost prevented from passing, then by closing it somewhat and rapidly opening and closing the main switch much the same effects can be secured. As the main switch is being opened and closed, with the other hand the spark gap can be opened gradually until the patient's tolerance is reached. The wider open the gap the more stimulating the effect, but, of course, the patient will object if it is made too painful. Practice the manipulation of the spark gap on both technics by placing the weighted ends of the two patient's conducting cords in a large vessel of water (being careful, if it is of metal, that the current does not short circuit from one cord around the pail or pan to the other cord and cut out the resistance which the water would interpose, because if this resistance *is not in circuit* you may ruin the meter or burn out the outfit) turning on the current and using the spark gap. In this way you can soon acquire the necessary touch to successfully carry out either technic and in addition acquire confidence in your ability. While the effects of diathermia do not in the least depend upon any element of suggestion—they are positive physical effects—yet these effects can be modified very greatly if the patient can plainly see that the operator is hesitant, timid, uncertain or patently afraid of the machine or the

Comparative Table of Differences in Sedative and Stimulative Technics

	Sedative	Stimulative
Beginning treatment	Slow and gentle	Rapid and almost rough
Timing of treatment	Long treatments	Short treatments
Manipulation of spark gap	Very slow and easy	Rapid and much wider open
Condenser	More condenser-less spark gap. (If a fixed condenser type then more street current and less gap)	More spark gap—less condenser (or less street current)
Terminating treatment	Gently—full minute or so	Instantly or nearly so
Dosage	High milliamperage	Low milliamperage

effects of his manipulation of it. The technic should be studied and practiced until the operator knows the reason for each step and can do it almost automatically. Then, when occasion arises, he can use it confidently.

Indications for Stimulative Technic.—This technic is used almost exclusively to stir up sluggish tissues. Nonunion in fracture is a classical example. The contraindications are practically the same as for the sedative technic.

CHAPTER VII

AUTOCONDENSATION. INDIRECT AND MODIFIED DIATHERMIA

Autocondensation is in reality a form of indirect diathermia. Instead of having two metal plates applied directly to the patient, one plate (or the equivalent metal cylinder held in the hands) is applied directly and the other is placed under a dielectric or insulating covering of sufficient insulating strength to prevent any actual passage of current through it. The lower plate is usually a sheet of metal of good conductivity, approximately the length and breadth of a patient or, in many cases, about five or six feet long and one foot or more wide, fixed to a table top or a special top to lay on a table and is covered completely with the dielectric covering. This insulating covering should extend at least two inches beyond the metal at all points and be fixed in this position so that it cannot slide off the metal, otherwise a very unpleasant, stinging shock will result to the patient. The patient, connected to one side of the d'Arsonval circuit by a metal cylinder held in the hands, is laid upon this autocondensation table or pad, the covered metal sheet of which is connected to the other d'Arsonval binding post and the treatment given.

The pad electrode acts as one coating of a leyden jar and the patient as the other, the insulating cover taking the place of the glass of the jar. At one surge of the current the metal is charged positively from the circuit and at the same instant the patient is inductively charged with the opposite polarity and at the next instant the process is reversed, the patient receiving the charge from the circuit and the pad the inductive charge. No current actually passes *through* the pad yet the meter registers a continual flow of current and the patient feels the heat, especially in the wrists and arms. The whole body heats up gradually, a feeling of relaxation and drowsiness comes on and, unless the patients' arms have been placed upon a pillow and the hands thus given support he is liable to drop the handle as he relaxes. Another reason for having a pillow under the forearms is that if they are allowed to rest upon

the body as soon as sweating starts and the clothes become moist, the current, instead of going on up the arms and into the body will short from the forearms directly to the body and this produces a stinging and very unpleasant sensation.

The current in its rushes to and from the body being concentrated to the comparatively small area of the arms, the patient will feel more heat here than anywhere else. The arms, spine, kidneys and structures lying closest to the metal strip underneath the pad are acted upon more intensely than other structures, of course. The nearer you approach the dielectric or insulation separating the patient and metal, the greater the density of current becomes. It has long been known that the thinner the dielectric of a condenser of a given size the greater the amount of electricity it would hold—in other words, the greater its capacity both to receive and hold a charge on the charging side and to induce a charge on the inductive side. It naturally follows that, all other factors being equal, the thinner the dielectric (insulation or pad) the greater the charge. To make it still plainer, with the same voltage, amperage, and frequency, a given dosage can be administered in a shorter time with a thin pad than with a thicker one. With the same factors otherwise, with a high voltage the same effect can be produced in a shorter time.

Changing the charging voltage very markedly changes the dosage, assuming that the same amperage is used. Thus while it might take with a given outfit and using the d'Arsonval circuit some fourteen or fifteen hundred milliamperes for about twenty minutes to give a full dose, if the voltage of the charging circuit is raised by hooking the primary and secondary of the Oudin in series a milliamperage of three hundred and fifty or four hundred is now sufficient. This is done by removing the conducting cord from one of the d'Arsonval posts (usually the one on the opposite side of machine from the meter) and placing it on the Oudin or Tesla terminal. The other connection is through the meter as usual.

It has been my observation that the average case where autocondensation is indicated will do better under the high voltage charge than under the low and for the last several years we have used the high voltage hookup almost exclusively. Where I formerly used the lower voltage, higher amperage hookup to get general heating effects, I now apply the diathermia direct. An instance is a case of chronic interstitial nephritis. Autocondensation in

these cases certainly will reduce the blood pressure to some extent but shortly after the cessation of the course of treatment (in spite of dietetic and other precautions) the pressure will creep up again. Autocondensation is a form of indirect diathermia and if indirect diathermia results in temporary palliation of symptoms but not in permanent betterment might it not be because, although the kidneys share in the general electrical saturation at each charge and discharge, the density of current in them was not sufficient to have any damping effect upon the "itis" itself?

The sequence of direct diathermia through the kidneys followed by the static condenser discharge over the same area for a couple of months or more with, once a week, a fractional dose of x-ray will do more permanent good than a course of autocondensation, however extended. If to this are added the markedly oxidizing, eliminating and antianemic properties of tonic applications of the ultraviolet light we have a treatment based upon physics, chemistry and logic and one that—in connection with the other usual treatment measures—will often be astonishing. The same treatment can be used in the subacute large white kidney of parenchymatous nephritis or the later contracted small white kidney, but caution must be used at first in these cases. I have never seen any alarming flare-ups where this treatment was being used in chronic interstitial nephritis, but have several times noted excessive reactions in the parenchymatous form, so much so that, especially in the presence of the large white kidney, I start these cases out very gently on the diathermia and give them as much ultraviolet as is compatible with the comfort of the patient. In these cases, as in all other organic pathologies, it is foolish to expect physical remedies to *restore* destroyed tissue. The best that can be hoped for in advanced cases is to *stop further destruction* by damping out the "itis" and to restore function in whatever undestroyed structure there is left if possible.

The clearing out of the choking debris in the shape of inflammatory exudates, fibrosis, etc., the resumption of function by decompressed glandular tissue and the removing of the toxic products from the circulation by chemical reactions initiated by the ultraviolet are much better done directly than indirectly and it has been my rule for many years to attack nephritis, hepatitis, myocarditis and such conditions with diathermia in preference to autocondensation. I am not detracting from the merits of autoconden-

sation at all. In the days when an indefinite diagnosis such as "rheumatism" or "sick headache" was acceptable then any modality having the vasomotor equalizing effects, the power to increase elimination by skin and kidneys and the heating effects (diffuse, but very often effective) possessed by autocondensation was almost invaluable. Value is only a comparative thing anyway.

Autocondensation is just as potent today as ever, yet who would be satisfied to get back to treating these cases indirectly where they have seen the results of direct attacks based upon specific diagnosis? Autocondensation still has a place in our clinic. Many neurasthenics receive it especially in alternation with the "neurovascular training" hydro sequence of Dr. Baruch. I often use it as an addition to the local attack in many toxemic conditions, but it is no longer our mainstay. Since the sedative technic has been perfected, diathermia and ultraviolet for local and constitutional effects have taken its place. In addition to increasing efficiency in given conditions, they secure results in days or weeks where it formerly took months or years and many conditions that responded only slowly or not at all to the indirect attack now respond so quickly that the referring physician often is loth to believe it possible and frequently decides that he was mistaken in his original diagnosis. It is rather a remarkable coincidence how many perfectly good diagnoses are changed after a well equipped physiotherapy service begins to function in institutions which previously had defended their diagnoses unto the death.

Autocondensation should not be given immediately after a full meal. Patients with an extremely high or low *pulse pressure* should be treated cautiously. Treatments in the aged or in advanced arteriosclerosis should be started gently and the patient watched closely the first few treatments. Tolerance may sometimes be established even in cases that react badly if a full treatment is administered the first time by shortening the time and reducing the quantity for a few applications. Pulsations of the neck vessels, excessive sweating, a feeling of uneasiness or faintness, muscular cramps in the arms, etc., are all signs that the dosage for the particular case is being crowded. The patient should feel no sensation at all except one of gentle heat and lassitude.

CHAPTER VIII

NONVACUUM ELECTRODE. (INDIRECT DIATHERMIA.)

All vacuum and nonvacuum electrodes act simply as condenser electrodes. If we were to take the ordinary leyden jars (condensers) out of a high frequency outfit, take the metal inside coating out (or, in case the inside contact is made by a salt solution, remove the solution) seal the jars and pump them to a vacuum corresponding to that of a vacuum electrode and replace them in their proper place in the outfit we would find that we had reduced their holding capacity (i.e., the amount of charge of current they would store) to such a small amount that the outfit would no longer work satisfactorily. The same thing holds for a condenser electrode. A metal lined condenser electrode has many times the capacity of a similar size rarefied gas or air filled electrode. Many kinds of gas have been used to fill these vacuum electrodes, but, while some of them give better service than a rarefied air filled vacuum electrode would give, and all of them look very spectacular with their intensely bright coloring, the fact remains that all of the vacuum electrodes—rarefied air or gas filled—are simply spectacular toys as compared to the nonvacuum electrode.

It is—or should be—evident that a given charge impressed upon one side of a dielectric *cannot possibly* induce a greater charge upon the other side. As these electrodes act by inducing charges in the tissues underneath their point of contact, and as the rule is that an induction charge is equal (approximately, never more) but of opposite polarity to the inducing charge and as the heat formed in the tissues varies as the *square* of the amperage (or charge) and as it has repeatedly been proved that a metal coated surface will hold many times the quantity of charge that an ionized air or gas surface of equal area will hold, it is hard to see where there are any grounds for argument. If the heat formed in the tissues varied only as the amperage, then these nonvacuum electrodes would still be many times as efficient as the vacuum ones, but as the heat formed varies *as the square* of the amperage

it can be seen that a condenser electrode having ten times the capacity of another is approximately one hundred times as efficient. It is hard to give the percentage ratio between *inefficiency* and *efficiency* but, whatever that ratio is, that is the ratio of efficiency between the vacuum and the nonvacuum electrode.

Experiments conducted at the Walter Reed U. S. Army General Hospital in 1918 demonstrated that the temperature of tissues a minor fraction of an inch below the point of application could not be raised by an application of twenty minutes of the vacuum electrode, yet by substituting the nonvacuum, using the same high frequency outfit, connections and settings on the machine, the temperature rise in tissues as deep as two inches down was immediate and marked. Thus the use of the nonvacuum electrode as a means of applying heat to skin or mucous membranes is even better than direct diathermia because the point of greatest heat then is on the surfaces in contact and in the area below such contact surfaces while in diathermia the area of greatest heat is somewhere between the two plates, the location of such area of greatest heat being governed by the relative size of the two electrodes.

A caution should be inserted here. The *largest sized* body nonvacuum electrode (bowl three to four inches in diameter) has sufficient capacity that if used very long on a small portable high frequency outfit or if used on a large outfit running from a *small rotor convertor* it may overheat and burn out either the high frequency machine or the rotor. We had this occur several times in our clinic before we would believe that such a thing could be possible.

The naming of the use of nonvacuum electrodes as indirect diathermia is for the same reasons that autocondensation is called indirect diathermia. The current does not surge straight through the tissues and electrodes from one side of the circuit around to the other and back as in direct diathermia, but simply enters and fills the condenser electrode and induces or repels charges to and from the distal surface of the glass. The nonvacuum electrodes are of glass, lined with silver and should *never* be sterilized by *boiling or placing them in chemical solutions* as this practice is sure to ruin them by loosening the silver from the glass. They should be cleaned by wiping the contact surface

with alcohol (denatured will answer) or rubbing such surfaces with soap (antiseptic if preferred) and water, care being taken to dry them if water is used and to prevent any fluids from reaching the inside coating. Properly used, these electrodes will

Fig. 18.—Indirect diathermia through the eyes by means of the nonvacuum condenser electrode. Note patient seated upon an insulated platform (which prevents current from diffusing and grounding through patient's and chair legs) and the current being grounded through the operator's arm and body. By this method it is possible to reduce the amount of heat as compared to direct diathermia and yet localize it as accurately as in the direct form.

give long service. We have often used the same electrode eight hours a day over a period of many months before replacing it.

There are three technics for the use of the nonvacuum—the sedative, stimulative, and the counterirritant.

Sedative Technic.—Apply thin dusting of talcum to skin, hitch nonvacuum electrode to Tesla or Oudin terminal of H. F. machine, apply surface of body electrode to skin and gently increase amount of current to tolerance and then lower it slightly, as otherwise it will have to be moved too often. Hold the electrode in firm contact until patient complains that it is getting too warm, then *slide* it the width of the electrode along the surface over the muscle, nerve, or area being treated. Hold it here the same way and return to first area again and repeat until area is thoroughly heated. This may take from fifteen to forty minutes depending upon the number of contact areas to be covered. Do not interrupt the current flow suddenly at any time by breaking it in moving switch contacts, etc., (without lowering the spark gap as in direct diathermia—which see) or by *lifting* up the electrode to place it upon new surfaces as each one of these interruptions imparts a stimulant touch to the treatment.

There are a number of ways of varying the technic. If the Tesla or Oudin terminal does not deliver as much milliamperage as is desired, then the treatment may be made bipolar. In this case a chair pad (autocondensation pad) may be attached to one side of the d'Arsonval circuit and the body (or other) nonvacuum electrode attached to the other side of the d'Arsonval circuit. The hand, foot or other part to be treated is laid flat upon the pad and the nonvacuum electrode applied to the top side and moved slowly over the surface. This gives a much heavier milliamperage than where the single electrode is used from the Tesla or Oudin terminal and fills the gap between the monopolar nonvacuum and the direct bipolar diathermia. In the place of the autocondensation pad another body nonvacuum electrode may be used. Another modification is to apply a metal plate in the same manner as for direct diathermia and in the place of a second metal plate use a nonvacuum electrode.

Stimulative Technic.—Electrode is attached to cord from Oudin or Tesla terminal. Turn on current until when electrode is placed upon and removed from your own hand or arm a shower of sparks

or an effluve about one quarter inch in length will jump from the electrode to your hand. Go over the anesthetic area or any area it is desired to stimulate by placing the electrode in contact with the skin and immediately lifting it up to a point where the current ceases to pass, replace it again, lift and repeat over the whole area until the skin has been reddened thoroughly. Any resistance placed between the electrode and the skin makes the application more stimulating and if enough resistance is interposed the treatment becomes counterirritating in character. A layer or layers of chamois skin may be fastened over the bowl of the electrode by tying with string or snapping rubber bands around the shaft or several thicknesses of woolen blanket may be laid over the area and the treatment given through this. If wool or silk is used keep the electrode moving or the material may be set on fire by the heat from the resistance to the current if the electrode is kept in one place too long.

Counterirritating Technic.—Attach electrode as before but turn on more current and open spark gap wider until a stinging shower of sparks passes when the electrode is approached to the skin. Turn the body electrode so that the edge is towards the skin and rapidly pass the electrode up and down over the course of the nerve, spine or area to be irritated, holding the electrode just far enough away from the skin so that a continuous shower of sparks will pass. Keep it moving as these sparks are almost intolerable if applied in a steady stream to a given small area for any length of time. The edge of an electrode so used becomes *very* hot and the electrode should be rotated at intervals to bring new surfaces into play. There is also a chance that the electrode may crack if it is laid upon a cold surface such as marble or plate glass immediately after being so used. It is best to lay it upon a dry folded cloth or towel until it cools.

Treating Mucous Surfaces.—Special electrodes are made for the various cavities, surfaces, etc. Here technic depends upon what it is desired to accomplish. If heat is being used to intensify the local reaction of ultraviolet—as in hay fever—then a considerable degree of heat for five, six or seven minutes is enough. If heat is being used for sedative effects or if it is being used to kill out infection—as gonococcus in the urethra or vagina—there a more moderate degree of heat applied for a much

longer time (30 to 60 minutes) is very much better. In urethral work, great care must be taken not to apply too much heat or a blister may result. Here, above all other places, a clean, flexible stabile spark gap is absolutely necessary. The flexibility and stability of gaps has been discussed another place and will not be repeated here.

Various technics and appliances have been advocated in the past for the use of some form of plus or minus heat in the treat-

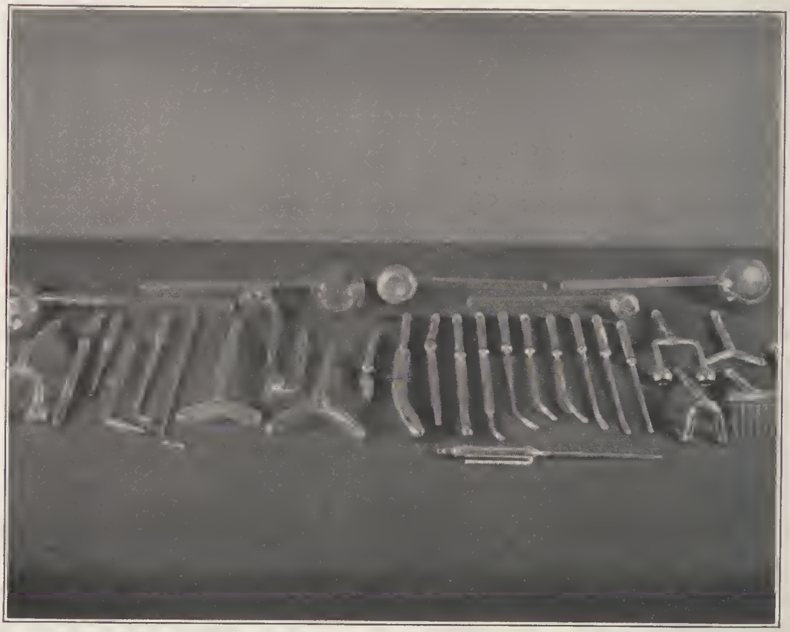

Fig. 19.—Vacuum and nonvacuum electrodes. The former were never used except in comparative tests to show superiority of the latter.

ment of that scourge of mankind—gonorrhea. Cold, or minus heat, has been proved to be so much less efficient than heat in this class of work that I shall not consume space discussing it. It should hardly be necessary to point out the dangers of some of these heat procedures, yet we are constantly being amazed both at the claims of some of the vendors of these appliances and at the number of physicians who are induced to invest perfectly good money in some of these outfits when a few minutes' careful study would show them the fallacy of the claims and

the dangers of the procedure. In the first place, conductive heat is the *least efficient* and most dangerous form of heat, and an overdose is followed by the usual destruction of contact tissue and the resultant scarring. If the infection were limited to the contact tissue and did not extend deeper and we could assume that there was no possibility of a burn, then the use of conductive heat might have something to recommend it as it would be possible to secure good results in some of these cases. Where good results do follow the application of this form of heat, it is because of the fact that the infection was superficial and the dry heat at no time exceeded the safety point. I was invited to witness a demonstration of one of the most elaborate of these conductive heat appliances at a certain large hospital and out of five cases treated three received burns of varying intensity. The method was immediately and justly condemned by the genitourinary staff of the hospital. The result amply confirmed our expressed doubt as to the safety and utility of the method.

Diathermia by means of a steel sound in the urethra and a metal or water-soaked electrode on the lower spine or buttocks has been advocated. A moment's consideration of the physics involved will show the fallacy of this procedure. An electrical current will not travel through human tissues if a dead short circuit of metal is provided for a considerable part of the way and this is just what is done when the steel sound is inserted into the posterior urethra. The current travels as far as it can on the sound and then forces its way across through the bladder to the other electrode. This means a dangerous concentration of current at the end of the sound unless the bladder contains water, in which case instead of a concentration of current there is a diffusion that renders it ineffective. Meanwhile, in spite of the most copious irrigations of the anterior urethra preceding the treatment, due to the distention and squeezing of the urethra incident to passing the sound there is almost always a particle of infective pus carried into the posterior urethra by the instrumentation, and unless the subsequent treatment can be depended upon to sterilize such infection, an anterior urethritis is converted into a posterior urethritis. This will result oftener than not in this method of treatment.

Another method has been advocated, and that is to use diathermia by means of a steel sound and tinfoil wrapped around the penis.

A study of the anatomy of the penis will show that most of the heat formed here will affect the floor of the urethra only and it has the further objection of being applicable only to the anterior urethra. Another procedure tried has been to drop the penis into a glass vessel of salt water and place the other electrode under the buttocks. Experience has shown that the patient will not tolerate the passage of sufficient current to sterilize by this method so that it can be ruled out although it has the advantage of not requiring the instrumentation of an acute urethra. For physical or anatomical reasons, therefore, direct diathermia can be ruled out in urethritis in the male.

Indirect diathermia, however, is not open to these objections. With a proper condenser electrode we could apply a uniform heat not only to the surface of the urethra, but to all tissues for inches in every direction. With a condenser electrode every

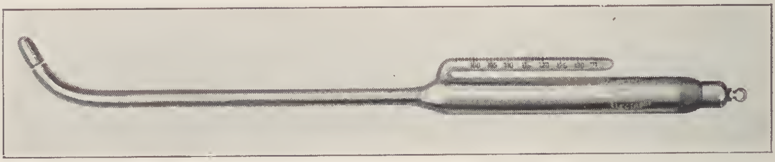

Fig. 20.—Urethral nonvacuum electrode for application of indirect diathermia. (Conversive heat).

particle of tissue touching its outside surface is subjected to *exactly* the same intensity of charge at all times (the charge on the metal lining is always exactly the same for each unit area) and with a proper high frequency outfit and—most essential—a flexible, stabile spark gap so that delicate regulation is possible and fluctuations avoided, we have a means of applying that very much more efficient form of heat—conversive heat—to the urethra and surrounding tissues and we have the further satisfaction of knowing that if, through any inadvertence a reasonable overdose of heat is applied, it will result only in a blister formation and not in scarring. Thus, both from the standpoints of safety and efficiency, the use of the condenser electrode as a means of applying heat to the urethral and periurethral tissues is indicated.

A couple of years ago an improved condenser urethral electrode was marketed; the nonvacuum. This electrode has a large reading

thermometer built into it. This thermometer registers—not the amount of heat formed *in* the electrode, because if the current be turned into the electrode when it is immersed in a grounded vessel of cold water and kept moving to prevent a jacket of warm water collecting around it, the current will pass as usual but the thermometer will not register any rise of temperature—the actual heat formed *in the surrounding tissues* and imparted to the thermometer by contact. Thus the thermometer gives an actual registration of the *temperature of the surrounding tissues* and enables the operator to regulate that temperature to a small fraction of a degree where a proper high frequency outfit is used. Because of its action in forming heat in the tissues themselves at some distance from its surface it will affect tissues that could not possibly be reached by any other means such as irrigations, conductive heat, etc. For this same reason it will do a sterilization in one treatment much oftener than any other means. If the infection can be treated at the itching meatus, slight serosanguineous discharge stage, one long treatment at a moderate temperature—106 or 108° F.—may be and usually is all that is necessary. Of course, *at any stage,* all the usual precautions preceding instrumentation would be used. If the condition is chronic or the posterior urethra and prostate are involved then direct or indirect diathermia to the prostate and bladder is a valuable addition.

CHAPTER IX

THE STATIC MODALITIES

There is more prejudice against static electricity than against electricity in any other form for several reasons. First, it is probably the least understood and, consequently, the oftenest misused form of all therapeutic currents. Second, the machines are difficult or impossible to keep in proper running order unless they are understood. Third, the imposing appearance of a large static appealed with an irresistible urge to the quacks and to that section of the medical profession to whom results are secondary to "front." (These men are rapidly being shown up and crowded to one side, but they are still far too numerous and powerful for the best interests of the profession.) Fourth, more sweeping and absurd claims as to what could be accomplished with a static machine were made by men who let enthusiasm substitute judgment because of a few remarkable results they accidentally secured than in any other branch of electrotherapy. I say accidentally, because it is a known fact that they *did* obtain a few remarkable results in *certain cases,* but were unable to explain them scientifically because of lack of knowledge either of the physics involved or of the changing pathologies of the various stages of the disease under treatment, etc., and were utterly unable themselves to duplicate these brilliant results with any consistency or to teach others to duplicate them because of this lack of a scientific understanding of the various factors involved. When a study is made of the technics used in securing these occasional brilliant results it is still more apparent that they were truly accidental. Literally hundreds and thousands of physicians were impressed with the claims of some of these men, purchased static machines, took a course of personal instruction, returned home and tried for some months or years to come up to within long range naval gun shot of the results promised, were unable to do so and gradually shoved the machines to the back of their office to be used only upon rare occasions, or discarded them entirely with the verdict that there was nothing to be gained by the use of a static machine. Manu-

facturers ceased making machines and even discontinued supplying repair parts. Now, however, since static technic has been made to conform to the physical laws governing condenser discharges, a revulsion of opinion has taken place and manufacturers are unable to keep pace with their orders.

Fifth. It is a queer trait of human nature that causes some men, when bested or when they realize that they are about to be bested in a discussion or debate (whether over physics, pathology, sweeping claims, politics, religion or technic), to try to avoid defeat by impugning the intelligence, veracity or honesty of their opponent and to start a personal fight. The winner of a verbal match has no need to resort to such tactics. Too often, physicians questioning some of these sweeping claims or demanding—what they have a perfect right to demand—proof or at least a rational, scientific explanation as to how the results were arrived at, have been the recipients of such a flood of personal abuse that they and their friends have decided that any method that must be defended by such tactics must have very little merit and so have dropped it. The static field has been particularly unfortunate in having had entirely too much of this mistaken idea of salesmanship used in the attempt to sell it to the medical profession. The resultant prejudice and disgust is very hard to overcome.

Physically, the static machine is an *exceedingly high voltage, self charging condenser machine.* Technic based upon any other conception of static electricity is necessarily wrong and it is only since the correct conception of the physics of the machine has resulted in almost a complete reversal of all old technics that the static machine has demonstrated its ability to *duplicate results consistently.* It has long been known that one of the effects of certain static modalities was that of decongestion yet from a perusal of many of the conditions where its use is recommended and the statement made that, so used, it would "cure" (chronicity seems to make no difference) I often wonder why plumbers do not carry around a static machine to decongest their frozen water pipes in the winter because, most assuredly, a simple frozen water pipe is an *easy* proposition compared to some of the "frozen" things in the human body that the static modalities are con-

stantly being blamed for not clearing up as per so and so's say so.

The static machine being a condenser machine, it is necessary to understand something of the peculiarities of condenser discharges before a proper technic is laid down. It was an exhaustive study of the physics of condenser discharges, their effects upon normal and abnormal human tissues, etc., that brought about the laying down of a proper technic for high frequency. Until it was recognized that high resistance anywhere in the circuit of a high frequency machine—spark gap wrongly constructed, too widely opened, dirty; internal resistance in the machine itself (magnetic or inductive); dry skin; dehydrated electrodes or what not—completely changed the character of the discharge from that machine and converted it from a *high frequency* into a *low frequency,* the technics used were more or less a matter of guess, good results were few and irritation where sedation was wanted was so common that the use of diathermia on all orthopedic cases was absolutely forbidden in the army hospitals until it was conclusively demonstrated that improperly constructed machines and poor technic were responsible for the almost unanimous bad results secured up to that time which had culminated in the order to cease using diathermia.

Low frequency condenser discharges are irritating both in proportion to their voltage and amperage. Experience has demonstrated that a condenser discharge of a certain voltage and amperage not sufficiently irritating to cause contractions in weak muscle can be made sufficiently irritating either by increasing the voltage or the volume (amperage). For instance, a single condenser section charging at 100 volts does not produce a contraction; change the rheostat until the charging voltage goes up to 125 volts and a contraction is produced. Or, leave the charging voltage at 100 volts and increase the capacity by cutting in another condenser section of exactly the same capacity as the first one, make the contact and a contraction follows. Thus it is easily proved that an increase in voltage or in capacity makes the difference between inefficiency and efficiency. When we go into the high frequency field we are dealing with much higher voltages—therefore with much more irritating discharges unless they are repeated rapidly enough to put them into the high

frequency field—and therefore demanding a very exact technic for their intelligent use and when we go on up into the *exceedingly high* voltage the static currents (the highest voltages used in therapy) we find still more reason for an exact technic.

In the high frequency field we found that the resistance of an air gap of more than a small fraction of an inch was sufficient to convert a true high frequency current into a rapid succession of single very irritating low frequency, *high voltage* condenser discharges. (That is, there was only *one* or, at most, very few condenser discharges from the original transformer voltage charge. The high resistance in circuit prevented any except the very highest voltages.) The original high voltage condenser discharge in a high frequency machine is—in the absence of high resistance—followed by a series of condenser discharges, each occurring at a slightly lower voltage than the preceding one and *the thousands of them* following the original charge as the result of induction in the circuit occurring in an exceedingly small fraction of a second (estimated at from 1/50000 to 1/75000 sec. for each whole series) from passing, thus making a *low* frequency instead of a *high*. It is absurd to speak of any high frequency effect in the tissues under a static electrode or spark where the air gap in the circuit is one of *several inches.* Such a thing is physically impossible, so why controvert over the statement that such high frequency effects do take place in such tissues? The static (so-called wave) condenser discharge is a single unidirectional condenser discharge and nothing else. The objection to the statement that all static modalities are simply condenser discharges (it is, of course, possible to rig up a real high frequency circuit by means of condensers and a d'Arsonval solenoid and run it from a static machine—*using a very short air gap between terminals*—but the milliamperage from the static machine is so small that it cannot compete with a good high frequency machine) has been made. "But, I never use leyden jars, therefore when I use static modalities I am not using a condenser discharge. Furthermore, how can you say that the brush discharge is a condenser discharge?" The static machine *itself* is simply a large, self charging condenser having a definite capacity. The addition of the patient upon an insulated platform or of accessory electrodes simply *increases* the capacity of the machine as

does the addition of properly balanced and connected leyden jars. The brush discharge is simply a continuously charging extremely high voltage condenser discharging through a *high resistance* (but not so high as an air gap of the same length as the active part of the electrode itself) thus being unidirectional and having polarity. These facts are so self-evident and simple that it is strange that they were not recognized and acted upon many years before they were.

The practice of giving the so-called wave treatment (static condenser discharge) without the leyden jars on is the equivalent to running an automobile always in second gear and placing a variable uncertain and *noncontrollable* regulator somewhere in the gasoline line and with a guiding control which functions only as well as the gasoline control. When the regulator functions perfectly (theoretically possible) you could get a certain amount of work out of the car and have control of its direction but would always have to be content with slow progress. Where it does not function properly you would get either too much gasoline or not enough, make poor progress and have no guiding control. Not many of us would continue to use cars if we had to contend with such a state of affairs *unless* we had never seen a car properly run. After trying the high speed gear, positive steering and nonobstructed and absolutely regular flow of gasoline we would not go back to the old way.

The addition of good leyden jars, *properly hooked up*, increases the capacity of the machine (therefore its effectiveness) sometimes much more than a hundred per cent and always markedly. In addition, with the proper jars and hook-up you have the *absolute* control of the frequency of the discharges so vitally necessary and which is utterly impossible when using the machine without proper jars and hook-up. The practice of hooking up a feeble patient with an irritable lesion to a static machine, starting it into full operation (without jars) allowing a perfect stream of discharge sparks to cross the gap at an uncontrolled frequency which causes painful tetanic contractions in the tissues under the electrode, and leaving him subjected to this treatment for an indefinite time, (governed by the convenience of the operator) sometimes over an hour and, when attention is called to the time, remarking "Oh, leave him alone for an hour, it will do him good,"

shows a very complete understanding of the nature of the case and treatment. Such things from an experienced teacher of static electricity show why these modalities are discredited in this country. (This is not fanciful. I actually saw this happen and upon inquiry found that it was used and taught that way.)

When Dr. Bishop, Dr. Morton or whoever it was that first used the static condenser discharge years ago brought out this so-called "wave," he discovered that the electrode when attached

Fig. 21.—Corner of the static section. Patient in foreground receiving direct sparks to spine. Patient in middle receiving the static effluve. Far patient receiving the static condenser discharge to spine.

to the positive pole was more effective than when attached to the negative pole. This procedure was adopted but not explained. The reason is that the negative pole on any polarity current is the more active upon the make of the current and the positive the more active upon the break, and it is the break that we are using in this case and in the case of the sparks, therefore the reason for always using the positive pole for the *active* electrode. It is wrong to connect the patient to the positive pole and use

the negative for the active electrode (the spark ball or point) when giving sparks, because a static spark is nothing in the world but a *concentrated condenser discharge* and the practice of using the negative pole for the spark ball or point is not only more painful but *less efficient,* therefore the reversal of the hook-up usually advocated for the giving of sparks. The same thing holds if the commonly and correctly taught hook-up for the brush discharge be changed and the patient attached to the positive pole. The otherwise sedative discharge is at once changed to one of a very irritating character of lessened efficiency because the brush discharge electrode (active) is now negative in character.

The static machine of the future will be known as a condenser machine and should be called the static condenser to distinguish it from other condensers. The technics for its use must conform to the laws governing the use of high voltage condenser discharges else they are bound to be wrong and inefficient as compared to technics that do so conform.

The word static means "at rest" and it sounds contradictory to speak of the static current. However the machine generating the current is named a static machine and, of course, the product is referred to as a static current. Some of the older names for the earlier types of machines were "Influence Machine," "Frictional Machine," "Franklinic Machine" and occasional reference is still made to the franklinic, influence or frictional current. The name probably was bestowed upon the machine from its property of charging certain capacities and of retaining a charge of electricity itself for some days or weeks after it has ceased operating, assuming that the machine is in good order.

There are three types of static machines in general use today but of these there are only two types in use in America. The Wimshurst machine is not used here but seems to be in quite general use in Europe. In this type of machine each succeeding plate turns in an opposite direction, i. e., the first turns counter clockwise, the second clockwise, the third counter, etc. It is not up to the other models either in simplicity of construction or all-round effectiveness so I shall not take up space in describing its construction and operation. Of the two other types, the Toepler-Holz and the Holz models, each has its adherents, but I believe the general verdict is that for all-round effectiveness—

and certainly this is my own conclusion after many years experience in the use of both models—the Holz model is preferable.

The Toepler-Holz model has circular glass stationary plates slightly larger than the revolving plates between each pair of revolving glass plates, has metallic buttons on the first and last revolving plates and stationary metallic brushes which touch these buttons as they go past, and is self-charging. This machine will charge and hold a charge under conditions where the Holz model would go dead and stay dead. Due to the positive and negative charges on the opposite sides of the glass plates with no insulating air space between, the machine has a constant tendency to neutralize charges by sparking across so that when the machine is operated under stress of a full load or at full speed there is a constant popping of sparks across, which is not only very annoying, but which interferes seriously with the obtaining of a smooth current from the machine and if the machine is not kept aired out and thoroughly clean the current delivered becomes almost unbearably faradic in character. At its best it is no better than the Holz and at any other point it cannot be compared. Its main asset is its ability to go along under abuse even if it does stage a miniature Fourth of July celebration while going.

The Holz model has divided glass stationary plates and as a consequence gives a much smoother current. It is not self-charging and has to have a Wimshurst charger mounted in one end of the case. To charge it the connecting cord from the front end of the Wimshurst is connected to the far pole of the static and the metal bar on the rear turned down by the knob at the front or back and the static started up with the plates revolving slowly. It is much easier to charge the machine with the plates turning slowly or at a moderate rate of speed than when they are revolving rapidly. Often when you are about tired of trying to charge it and cut off the static motor and the plates begin to slow down you give the Wimshurst a parting spiteful turn or two and the charge takes to your surprise and delight. The main terminals should be placed one-half inch or more apart and if the Wimshurst will cause a spark to cross this gap you can almost surely succeed in charging the machine. If the Wimshurst charger will not give at least a half inch spark it had better be cleaned

up. Take the end of the case covering it off, see that the brushes are riding *against* the surface of the two plates, clean them if they are greasy or dirty and take a very lightly alcoholed rag, turn the glass plates of the Wimshurst rapidly and then hold the alcoholed rag against the revolving glass plates from the edge of the plate to a width reaching inside the path where the brushes bear for one or two full revolutions and then quickly substitute a perfectly dry, clean and lint-free rag and dry the

Fig. 22.—Another corner of the static section. Patient in foreground is receiving the static effluve to the hand. Patient in center is having a flexible metal electrode fitted to the cervical spine for a static condenser treatment. Patient in distance is receiving the static condenser discharge to spine.

alcoholed path. If this is done quickly and too much alcohol is not put on the first rag, no harm will be done to the insulation of the plates and this cleaning will often result in a very marked gain in the amount of current the Wimshurst will generate. Also clean the contact end of the fine wire brushes.

If a static machine is kept in proper condition, aired out frequently, cleaned up inside and out and the insulation on the plates

not rubbed or scraped off by allowing the machine to keep on running after a scrape or rub has appeared, there is no reason why it should not *charge and run* in any kind of weather. A good static outfit costs about as much as a medium or low priced automobile and requires no more attention than a car to keep it working efficiently—in fact, not so much—yet how many physicians who would not think of allowing their car to run weeks and months without cleaning, oiling and adjusting, will expect their static machine to give constant service for months and years without a bit of attention and then will become explosively profane because the machine refuses to operate further.

Placing the Static Machine.—A static machine should never be placed in a damp basement; near to a brick wall that is in position to gather and hold dampness; near to any wall (12 inches clearance is absolutely essential and 20 is better) and especially should never be crowded against a radiator or metal pipe of any kind. To prove the wisdom of this statement, place a good machine in such position and some dark night cut off *all* the lights, start the machine up into full operation, open up the terminals widely and then look behind it and see the beautiful effluve the leakage makes. If it cannot be seen, it can be felt if the hand is placed between the machine and pipes, radiator, etc. Some months ago I had a very good illustration of the presence of a big effluve even though it was almost entirely invisible to the eye. We were taking a series of moving pictures and when it came time to take the static section the atmospheric conditions were such that only a very faintly visible effluve was obtainable. Two of the machines were being cleaned up and repaired and each of the other five seemed to give about as weak an effluve as the other. As the director was taking his camera crew to other sets the next day we decided to shoot it anyhow even if we had to retake it at some other time. We hung a dark blanket behind the effluve to bring it out but even then it had to be viewed from a certain angle to be visible. When the film was developed the effluve stood out like a whisk broom, without any retouching whatever, and was one of the plainest scenes photographed. If it is possible to place the static machine on the second or third floor, so much the better, and if there is a place where the sun can reach it daily, the problem is half solved. Composition plate statics should never

be placed in the direct sunlight as the plates will warp quickly if direct sunlight strikes them.

Foul air in a static machine is much more destructive to its efficiency than moisture in the long run. Nitrous oxide and other gases are constantly being generated when the machine is in operation, and if allowed to concentrate will settle all over the inside works, condense into a sticky, gummy deposit which not only catches and holds dirt, dust, etc., but is hygroscopic and will *hold* moisture once it attracts it.. The machine should be given an airing at least once every twenty-five hours of actual running, but, of course, a time should be chosen when the humidity is low, if possible. We have aired our machines even when the humidity

Fig. 23.—Static effluve to hand enlarged from film and unretouched.

was excessively high, as between moisture and a foul interior, we preferred the moisture. The ends are taken out of the machine and it is run for twenty minutes or so, or an electric fan is played into it while running for a few minutes with the ends and top off. The interior should be gone over, (the office assistant can do it regularly) with a rag lightly moistened with crude oil or, if this is not obtainable, with kerosene; this is followed by rubbing with a clean *dry* rag. I take a yard stick, wrap it with oil moistened bandage, lay it in between the revolving plates with one end resting upon the axle and turn the plates by hand, slowly, and rub them off. Then I lay a thin towel over the stick and turn the plates toward me, making gentle pressure against them, thus cleaning them too. Gases will not gum up a machine so

treated, as even if they condense they come off easily at the next cleaning.

Adjustments are provided for moving the stationary plates and collector combs to right or left as needed to clear the revolving plates. The machine should never be allowed to *run a minute* with a scratch or rub in it. This destroys the insulation very rapidly and once the insulation is destroyed over any considerable part of a plate (even a single scratch furrow around the plate

Fig. 24.—Static sparks in case of arthritis and the effluve in a case of catarrhal deafness.

where a single comb point has moved over touching the plate) that plate is worthless as the charge collected on one field piece simply jumps across to the plate, runs up or down the furrow, jumps and neutralizes the opposite charge from the other side so this group of plates is dead. It is common sense and economy to stop the machine and adjust it even during a treatment if a rub or scratch appears.

A couple of slat boxes (plaster laths answer nicely) are made

about three to five inches wide, eighteen to twenty-four inches long and twelve or fourteen—or more if there is room under the axle—inches high. Thirty or forty pounds of *unslaked* lime, (hard, finishing lime is best) is secured and these lumps laid in the boxes loosely to allow for expansion. The boxes should be half full or more. Powdered lime is of no value and when the lump lime crumbles or powders, it should be taken out, thrown away and replaced with hard lumps.

These lime boxes are covered with two thicknesses of muslin (gauze will not answer) sewed loosely around the boxes. If this muslin is tacked to the boxes, as soon as the lime begins to slake and expand it will rip the muslin and fill the static case with lime dust. Our custom is to fill the boxes as described, take a muslin pillow slip, pull it over the box, sew the end with an over and over stitch, turn this end from us and pull another pillow case over the whole thing so that the sewed end of the first pillow case goes to the bottom of the second one and then sew this second one in the same manner. The slack cloth is folded under and the box set upon the fold. This will hold the excess cloth out of the way of moving parts and yet allow it to give without ripping as the lime expands. I have never had any trouble with lime dust since adopting this simple procedure. The lumps should be felt between the slats at intervals of a week or two and when they soften and crumble to the touch the lime must be replaced. As a rule refilling once a winter and two or three times a summer will run the year around. In excessively humid climates more frequent renewals may be necessary.

When the machine leaves the factory the plates are all balanced up and perchance they are spotted. It is impossible to get perfectly balanced glass plates, but by properly turning them on the axle so that as many heavy sides come to the right as to the left they can be balanced so that the machine runs smoothly without vibration. If they have been spotted at the factory and are still where they were placed a black spot will be found on the edge of each plate and all of the plates will be turned so that the black spots form a straight row through the machine from front to back. If the front plate spot is turned to any given point, each succeeding plate spot will lie directly behind it. If the plates become loosened and turn on the axle, some of these

spots will creep around and they will be found hit and miss. It is an easy task to loosen the set screw holding the axle nut up against the plates, back this nut off a turn or two and gently but firmly push or pull these plates back into alignment. If the plates have not been spotted at the factory and the machine is pounding or vibrating when run at high speed, throw the drive belt off and see whether the plates will stand at any point they are placed, or whether, like a bicycle wheel, the heavy side will always go to the bottom. If the revolving plates turn more than two or three inches after they have been stopped dead still and let go, too many heavy sides are down. The axle nut is loosened as before and then first one and then another plate is turned one half the way round on the axle until a point of exact balance has been found. The axle nut should then be tightened firmly against the plates, the set screw set down tight to hold it there, and the plates spotted. Take a small camel's hair brush, dip it into some black paint, steady the circles and make a row of black spots from back plate to front plate on the edge of the plate so that the spot on each plate is exactly level with and opposite the last one. Then at a glance one can tell when any plate begins to creep and the assembly to go out of balance. Nothing tears a static machine up faster than to run it out of balance. Once the machine is properly adjusted, cleaned and set correctly it requires a very small amount of time and trouble to keep it at peak efficiency. It must be placed so that it sets level. If necessary a spirit level should be used to level it up.

Some method of varying the speed of the revolving plates is necessary if the best use of your machine is to be obtained. It is essential to be able to speed them up on heavy condenser treatments, effluve, etc., and to slow them down when giving indirect sparks or giving the condenser discharge over delicate structures like the eye. If there is direct current in the office or hospital the problem is easy, as a large rheostat with many contacts on it will give a wide range of speed for the driving motor. If there is nothing but the alternating current then recourse must be had to a mechanical speed controller or the purchase of a very expensive alternating current specially built motor, wound so as to give a selection of speeds. The mechanical speed controller (which is usually a movable friction disc and plate affair) is noisy, re-

quires attention and, in general, is not so satisfactory as it might be. The mistake of trying to run a static machine with too small a motor should not be made. An oversize motor will give a slow speed range impossible to obtain with a motor only just large enough to operate the machine at full speed. The difference in cost and operation is a very small consideration when the increased efficiency obtained from having an oversize motor is considered. On the direct current I use a one-half horse power motor on eight and ten revolving glass plate machines, a one horse power on a sixteen and a two to a two and a half horse power on a twenty-four revolving plate. With these horse powers and a proper control rheostat the plates can be slowed until they are just turning over without stalling the motor.

Grounding.—To get anything like efficiency from a static machine good ground wires are absolutely essential. A good ground connection at least doubles the value of the condenser discharges, and is necessary for an effluve and useful in other places. A piece of insulated copper wire about size No. 10 should be used. The earth end should be scraped free of insulation and brightened for some inches and a water pipe scraped until bright, the freshly scraped copper wire tightly twisted around the water pipe and *firmly soldered* with a blow torch flame. A twisted wire connection without the solder will rapidly oxidize and gradually throw an increasing resistance into the ground line and progressively lower the efficiency of the machine. The local telephone company will very probably object *if* they are asked whether it is all right to use the same pipe they have grounded, but outside of a clicking in the receiver at each discharge across the terminals when condenser discharges are being given I have never known of any damage to a phone set from the use of a common ground. (Note: This clicking will occur anyway in any telephone set near a static machine whether grounded to the same ground as the telephone set or not.) Another way to ground is to drive a long metal pipe, five or six feet into the ground (in the eave drip or under a roof spout if possible) and solder the ground wire to that. I have never known of a fire to result from one of these ground wires where it goes through the wall, but it is conceivable that a small spark *might* occur, therefore it is well to use a porcelain tube insulator where the wire goes through the wall.

Steam radiators or pipes will answer for a second or separate ground in treatments requiring both one side of the machine and the treatment electrode to be grounded but are not as good as water pipes or the ground described. Never, in any circumstances ground either to an electric light fixture or to a gas fixture. The exceedingly high voltage of static will walk right through the insulation on ordinary light wires, and once the puncture is made through the insulation the low voltage current carried on these wires will arc through to another wire, the conduit or other places and either blow fuses or start a fire. The danger of a spark occurring on a gas pipe near a leak and causing an explosion is always remotely present if a ground is made to a gas fixture.

The connection end of the ground wire should *never* be tacked, laid upon, or under or fastened *to, any part* of the static machine itself, as a serious loss of current from the machine is *always* taking place in this case when the machine is running even if neither pole is actually connected to the wire. Repeatedly I have seen big, fine machines grounded in this manner. The best place and the handiest for the ground wire is to have it stretched overhead, parallel to the front of the machine, about eighteen inches in front of a vertical line reaching from the front side of the machine to the ceiling and at least two or three feet above the machine. This gives more than three feet clearance when not in use. Skin the insulation from the ground wire at a point over and opposite each main terminal on the machine and provide several pieces of fairly stiff, bare copper wire some three feet long. Bend a hook into one end of this wire and take a piece of coarse link brass chain and fasten into a ring bent onto the other end. On the free end of this chain fasten a copper or brass hook. When it is desired to ground one side of the machine all that is necessary is to hang the hook end of the wire over the ground wire on one of the bared wire spots and lay the hook on the end of the chain attached to the other end over the rod of the main terminal on that side of the machine. It is thus only a second's work to make or break the ground connection or attach an electrode to the ground wire and when the ground connection is not wanted it is out of the way at all times.

Testing for Polarity.—There are several methods for determining the polarity on a static. To prevent confusion I am not going

to detail them all, but will describe a very simple and always reliable test that I have found to be the best test in all circumstances. The machine is started into operation and the main terminals separated about four inches. Take a dry piece of pine or other wood, preferably round and eighteen to twenty-four inches long. (A piece of dowel pin wood from any turning shop is ideal.) Approach one end of this wood at right angle to and roll it over one of the terminal balls and then the other. On the

Fig. 25.—Testing for polarity on static. Wooden rod is being held on the positive pole.

positive side the current *will* follow the wood and on the *negative* side it *will not*.

A static machine in proper adjustment and kept clean will run for months and years with the same polarity all the time provided that in cleaning or adjusting it, it is not turned backwards. Sometimes the turning of the revolving plates less than one half revolution backwards will reverse the polarity. If the plates become loose on the shaft or axle, the heavy sides will soon all be down

when the machine is at rest. If the machine happens to stop with the heavy sides almost at the top, often the extra weight of these heavy sides will cause the whole assembly of revolving plates to turn backwards until the heavy sides are at the bottom and this is frequently sufficient to reverse the polarity. If the case is allowed to become very foul from accumulation of gases the machine is prone to change polarity frequently—sometimes while change of adjustments is being made in a single treatment. It is nothing unusual for a machine in this condition to reverse polarity a dozen times in a day. There is no reason why a machine, properly balanced, handled, and kept clean should change polarity, and if a machine starts to changing polarity it is *prima facie* evidence that the interior needs cleaning and airing, that the circles need balancing or that the operator is unthoughtfully turning the circles backwards occasionally in some movement around the machine. Most static machines are made for the circles to revolve counter-clockwise but Waite & Bartlett used to put out one made to turn clockwise. The age of a static machine has nothing to do with its efficiency. I would much rather have a twenty-year-old machine that had been kept clean and adjusted than to have a twenty-week-old one that had been used hard without cleaning, airing, or adjusting. The old one would go right along at top efficiency, whereas the new one probably would have to be dismantled, thoroughly renovated and given a factory going over before it could be made to deliver anything like a normal output. Luckily, a static machine only becomes cranky under much provocation.

The static current is an exceedingly high voltage, very small milliamperage current, having a distinct polarity. The best and largest glass plate machines seldom turn out over one milliampere and most of them only a fraction of that and yet on account of the exceedingly high voltage this very small amperage is sufficient for all purposes except the energizing of an x-ray tube. Increasing the number of revolving plates increases the amperage or volume of the current, but it is impractical to increase to a number that would give enough current for operation of an x-ray tube at satisfactory or practical milliamperage. Increasing the speed of the revolving plates also increases the volume of current. Increasing their size or diameter increases the voltage of the cur-

rent generated. As it is unsafe to speed up a glass plate to more than four or five hundred revolutions a minute on account of danger of breakage from vibration, centrifugal pull, etc., resort has been had to composition plates that would stand revolving at a high rate of speed. These plates are made of compressed paper, silk, mica, fiber or other similar material. These machines work beautifully for a while but I have yet to see one of them that would stand the gaff of eight hours a day continuous service for more than a few months. The plates warp and the constant vibration of high speed use gradually causes the compressed layers to open up a trifle. The gases work into the spaces between laminations and once there, condense, attract *and hold* moisture and soon have enough water in them that they automatically short circuit themselves so that they cannot be made to charge or to hold a charge if they are charged from some outside source. Once these plates become saturated, there is only one way to remedy the trouble and that is to throw them away and replace them with new ones. The smaller the cubic air content of the case, the sooner may this state of affairs be seen. When some nonlaminated substance with much greater cohesion, no greater porosity and practically all the good points of glass is discovered or invented then may we hope for a practical, long life, high efficiency, high speed static. From an x-ray therapy standpoint this is much to be desired. My own experience and that of almost every x-ray therapist who has used static x-ray as well as transformer outfits has been that with equivalent dosage the static x-ray is much more efficient. Nearly every man has a slightly different theory as to why this is so but nearly all say that it is true. I am only stating the apparent fact and shall not consume the space necessary to give and discuss the various theories. I think it is only fair to state that for intermittent use a composition plate static might give and often has given satisfactory service over a period of years in other hands but as I am giving my experience in the present work I am stating things exactly as they happened without fear or favor. For my part I shall continue to favor the glass plate machines until improvements eliminate the faults enumerated.

I am often asked, "If you could have only one static machine, what size machine would you select?" I should choose as large

a machine as my means and office space allowed me to install up to a twenty-four revolving plate machine. With such a machine *no* phase of static is closed from the most massive condenser discharge of a spinal treatment to the most delicate technic used in treating optic neuritis. The most common compromise is a sixteen plate machine, and this will do practically as good work as the twenty-four plate except possibly in the sciatic neuritis of an extremely large man or other very heavy work, and with the reducing of the area covered by any one electrode so as to secure the same current density. Some of the most brilliantly successful static work I have ever seen was done at General Hospital No. 9 with a very old eight plate Van Houten, but three applications had to be made to cover an entire spine while with a twenty-four plate the same thing can be done in one seance.

It is not necessary to have a thousand dollars worth of fine accessories to do good static work. A large and a small ball tipped spark electrode, a pair of De Kraft blue pencil effluve electrodes, a supply of 22 gauge crookes metal for condenser discharge electrodes and a few elastic bandages are sufficient. A long, round wooden stick (such as a thirty inch length of the dowel pin wood) with a screw hook screwed into one end is useful for connecting and disconnecting ground wires while the machine is running and the plain wooden end may be used to test polarity.

There is no danger to life whatever in even the largest static machine *provided* that the patient is not afraid of it. The operator should take pains to reassure every new patient of the absolutely harmless nature of this flashy current and if he cannot be convinced of this and he shows obvious terror of the outfit after such assurance, then it is wise to treat him with other means. Some years ago the daily press published an account of an initiation carried out by a secret society of electricians. On the wall of the lodge room they had installed a large switch and bus bars. The wires leading from this switch simply stuck through the wall and ended in the open air of the next room. No current of any kind had ever been connected with or passed over this switch so that it was "absolutely harmless." During the course of the initiation the talk was led around until the impression was given the candidate that the society was composed only of "current hogs" or those able to pass large amounts of current through their bodies with-

out apparent effect. He was blindfolded, taken into an elevator, shot up and down until he was supposed to have arrived at the main switch room of the building, led back into the lodge room and up to the big switch and bus bars. A pair of mates with rubber gloves on seized either wrist and raised his hands until they were just a few inches in front of the bus bars. His hoodwink was then suddenly removed and before he had had time to orientate himself and against his almost frantic efforts to prevent it, his

Fig. 26.—Collection of static electrodes. The larger blue pencil and the wide flexible metal spinal electrode are for use on the extremely large static and the narrower metal ones for use on the smaller machines. The glass plate and the roller are for use in rolling down and smoothing the metal electrodes after use.

hands were forcibly laid upon the terrifyingly large bus bars. The mental shock killed him. It was subsequently proved that his heart and general physical condition was far above the average, that he had passed for large insurance policies, etc., so that organic defects were ruled out. This teaches the very real danger of fear. It is well to impress upon patients the safety of high frequency

and static treatments and to assure them that should a spark or short circuit accidentally occur, such occurrence, while painful for a moment, is in no wise dangerous. I often assure patients that the entire outfit of a static machine would not kill a mouse, and this is literally true. I once discovered an arthritic mouse among a colony of mice and proceeded to give him the regular static treatment for arthritis. His improvement was manifest from the time the first spark hit him and during the twelve days of subsequent observation he covered more mileage, ate more food and, generally, was livelier than any of the untreated controls.

An insulated platform with glass (or other insulating substance—glass is best) legs, ten to fifteen inches long is included with every static machine sold. So are leyden jars. For eight and ten plate machines these jars should be of medium size; for sixteen and twenty-four plate machines of large size. In giving the hookups for the various modalities the patient will be referred to as P., the insulated platform as Pl. and the leyden jars as "jars." The leyden jars are connected up as follows: The *inside* coating of the jar is connected through the lid up to the main terminal of that side. The other jar is connected to the other main terminal in like manner. The jars usually sit on a metal base on a wooden shelf in front of the machine. If there is a lever on the machine marked "Spark" "Spray," etc., move the lever over to "Spark." If there is no such lever, the bases or outside coatings of the jars should be connected with a copper wire or the jars set upon a strip of crookes metal extending across from one jar to the other so that the outside of the leyden jars are metallically connected.

Hookups

Condenser Discharge

(Usually called the Morton or static wave.)

P. on Pl. to *positive* pole (wire from electrode on patient to Pos. pole on machine).
Jars on and *connected as described.*
Neg. pole main terminal grounded.
Main terminals closed to touching or very near, and opened to regulate speed of discharge properly after machine is going.

Direct Sparks

P. on Pl. to *negative* pole.
Pos. pole grounded.
Spark ball grounded to same or separate ground.
Leyden jars not connected up.

Indirect Spark

P. on Pl. to *negative* pole.
Pos. pole *not* grounded.
Spark ball is grounded.
Leyden jars not used.

De Kraft Blue Pencil Effluve

P. on Pl. to *negative.*
Positive side grounded.
De Kraft blue pencil electrode grounded.
Main terminals wide open.
Leyden jars not used.

Static Induced

Use of platform optional.
One electrode to base or outside coating of one leyden jar.
Other to outside coat of other leyden jar.
Bases of jars are *disconnected* for this modality.
(Two outside coats of jars are *not* connected.)
Main terminals closed, and opened very cautiously after machine is started.

Static Saturation

P. on Pl. to negative pole.
Pos. pole grounded, or vice versa.
Main terminals open wide.

Technic.—By remembering that in all modalities where the patient is placed upon the insulated platform *except* the condenser discharge (static or Morton wave) he is connected to the negative side of the machine much time and worry over proper connections can be saved the one beginning to use the static machine. By remembering that the distance apart of the main terminals is one of the control factors in all modalities *except* that of saturation (where the full capacity of the machine is desired from the start) the operator can instantly remember where the main terminals should be placed. By remembering that grounding is used to *increase* the output of the machine and that it is only omitted to weaken down the current he will see that in giving *indirect* sparks, for instance, the reason indirect instead of direct current is used is that the direct spark is too strong and naturally one of the first steps taken to weaken the current would be to unground it, he can solve the grounding problem while he is adjusting the main terminals, etc. It will come to pass in a very short time that the operator will automatically make the correct hookup without giving it a thought. The instructions may be typed on a small card

and stuck on the end of the machine nearest the control switches, or tacked on the wall beside the switch where they can be consulted instantly. If the patient to be treated is a woman be sure and have all celluloid or other violently inflammable ornaments, hair pins, etc., removed before starting the treatment. Metal in the form of corset stays, hair pins, etc., sometimes condenses enough current to sting and burn uncomfortably and in all cases watches should be removed as they will sometimes electrify and act very erratically for days, weeks or permanently if kept on the person undergoing the treatment.

Condenser Discharge.—In giving the condenser treatment the metal electrode is cut to proper size and shape, skin and electrode lathered freely with a nonirritating soap, the electrode laid on the surface and adapted to the conformation of the part, a folded towel or other light object placed *over* it and an elastic bandage applied in such a way as to hold the object pressing upon the metal plate during the treatment. The metal plate is connected to an insulated wire with a hook through an upturned corner, etc., or by use of a fahnestock clip such as is used in diathermia. As there is considerable muscular movement under the metal, it is well to use the whole fahnestock clip instead of one half as in high frequency treatments so that there is less likelihood of the cord pulling off onto the bare flesh outside the plate and causing an exceedingly painful concentration of current. In high voltage currents like static and high frequency it is not essential to have an absolutely tight, clean connection as it is in the low voltage currents so that the pressure of the clip under the elastic bandage on the metal is a good enough connection. A large wire or metal hook can be attached to the other end of the conducting cord and hooked over the sliding rod of the positive main terminal. The throw switch which cuts the current into the rheostat should be closed, the rheostat lever moved up until the machine gains good speed and then the main terminals pulled open until the discharge takes place across the terminals about twice per second. For a stronger current the speed of the revolving plates should be increased (never over 500 revolutions per min. and unless the machine is running very free from vibrations not over three or four hundred) and the main terminals separated

further. To decrease intensity of local contractions, under the electrode the machine is slowed down, sliding rods approximated to proper point or *size* of metal electrode on patient increased, which *decreases* density per unit area. As a rule the toleration of the patient can be accepted as a guide.

In acute sprains and in the neighborhood of adhesions any effective intensity will cause discomfort at first but as a rule these treatments cause little pain. In acute trauma such as a sprain or strain this treatment alone (with the aid of adhesive or other light splint for a few days) will work wonders, but if the exudate following such injury is given time to "coagulate" or partially solidify then diathermia must precede it. The same holds for acute "charleyhorse" (but not one that is an acute recurrence of an old one: there are elements of chronicity) myositis, etc., but if these conditions are more than a few hours old then recourse must be had to conversive heat to soften, open up lymph channels, produce hyperemia, etc. The static wave is superior to manual massage as a follow up after diathermia where anatomical configuration will permit of its use. The most delicate and finely trained human touch is decidedly traumatic in character when compared to the massage of a properly administered static condenser discharge. It is not properly administered if it is given strong enough over an acutely inflamed nerve to produce massive, crushing contractions of surrounding musculature. Used this way it is little better than manual massage which is contraindicated. Used in a proper manner it gently produces a mass, a molecular, an atomic and even an electronic vibratory massage and can be used with benefit where any other kind of a massage would only add insult to injury.

There are conditions in which it is desirable to obtain all the contraction producing power that the machine will deliver, but *acute* neuritis is not one of these. In subacute or chronic neuritis we have a different pathology with which to deal. Here it is desirable to obtain the softening, flushing, dilating, solvent effect of conversive heat followed by a *heavy* condenser discharge to break up and squeeze out into the dilated blood and lymph spaces the semi-organized and organizing inflammatory exudate and ionizing doses of a soft x-ray should be given to add the chemical

solvent effects upon this exudate and help clean it out. The treatment of no case of neuritis is *complete* without this addition. Be sure that the treatment has been applied at the right place before condemning it as inefficient. Many years ago I had a case

Fig. 27.—Static condenser discharge. Metal electrode over cervical spine and patient charging and discharging in synchronism with the leyden jars.

of brachial neuritis that would apparently clear up under this treatment—at least subjective symptoms were relieved during and for days and weeks after treatment—and which would recur in spite of all preventive measures. The case had started from the use of a crutch while the patient was convalescing from a

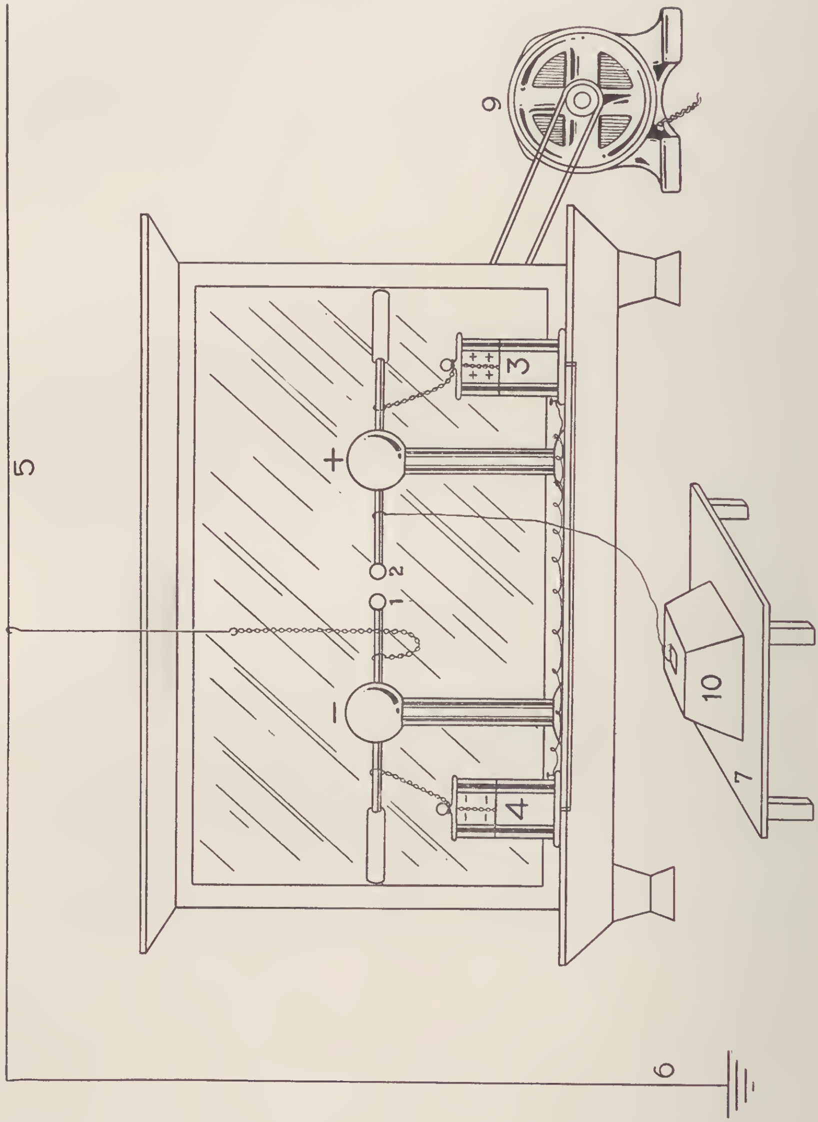

Fig. 28. (For description, see pages 135, 137 and 141.)

wrenched knee and he had developed a typical "crutch paralysis" when he presented himself for treatment. I finally realized that an "itis" of a nerve was not compelled to travel down only and might follow back up the nerve. I was busy at that time, together with a large part of the profession, in jeering at a recently launched spinal reflex theory and had almost reached the conclusion that it was quackish even to examine the spine, but finally decided that if I did not some one else probably would, and I was afraid of what he might find. The patient screamed and almost fainted when I prodded vigorously at the side of the spine over the exit point of a nerve to this plexus. I transferred my attention and treatment to this section of the spine (6th, 7th, 8th cervical, 1st, 2nd, 3rd dorsal) and when the condition cleared up this time it remained clear. A close examination of the spine will frequently save many weeks of time and this often when the physician is sure that he has a simple localized myositis to treat. An unsuspected cervical rib may cause recurrence after recurrence of brachial neuritis until spotted and removed.

There are many reasons for the use of the leyden jars. Best results can only be had when the contractions under the condenser electrode occur at regular intervals allowing a period of rest between each contraction and giving the tissue, in addition to a rest, time to fill up with blood and lymph before again being contracted. In this way much detritus is removed which would not be done were the tissues thrown into a chronic tetany and held that way such as results when the discharges occur too rapidly. With the jars on and connected across the base not only can the rhythm be regulated so that the discharges occur at exact intervals, but *much more than double* the effect

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Fig. 28.—Hookup for static condenser discharge. Patient on platform with the electrode connected to the positive pole. Negative pole is grounded. Leyden jars are connected to their respective sliding rod terminal and are connected across the base in the manner described in the text.

NOTE: In this and the five figures immediately following the numbers inserted in the drawings refer as follows: No. 1 to the negative pole; No. 2 to the positive pole; No. 3 to the leyden jar on the positive side; No. 4 to the leyden jar on the negative side; No. 5 and 6 to the ground wire; No. 7 to the insulated static platform; No. 8 to the electrode on the patient's skin; No. 9 to the motor for turning the static machine plates; No. 10 to the patient.

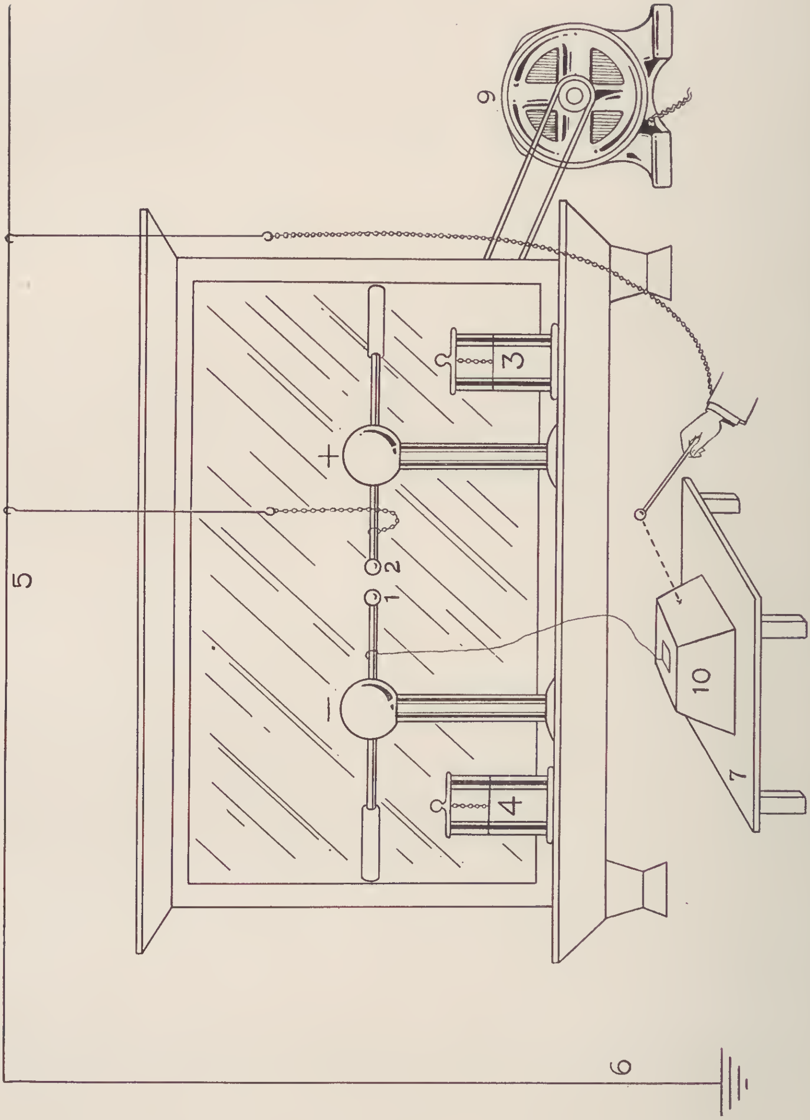

Fig. 29. (For description, see pages 135, 143 and 144.)

is secured by adding to the capacity and imparting a peculiar quality to the discharge that makes it less painful than the same capacity wave would be given in any other manner. I have tried every possible variation and find this hookup to be the best. For fourteen years I have not used any other except occasionally in a series of clinical comparisons. The condenser discharge given without the jars on cannot be controlled. If the machine is speeded up to secure more current the discharge flares across the terminals in a stream, tissues are thrown into irregular and tetanic contractions, the effects are much less sedative and the condenser discharge not nearly so effective. If the machine is slowed down in an attempt to regulate the rhythm of the discharge across the terminals when not using leyden jars, the amount of current is decreased. Even when the machine is operating to capacity without the jars, the induction is much less than when the jars are on and the machine running much slower. The addition of the jars adds tremendously (with the extremely high voltage used) to the capacity of the machine.

There is only one objection to this method of using the static machine, and that is one of noise. It *is* noisy. So is a twenty-inch naval gun noisy as compared to an ordinary hand rifle. However if the noise is decidedly objectionable a muffler can be used which will cut the noise of the discharge to a very weak sound. The muffler is simply an enclosed spark gap and will have to be cleaned as often as condensed moisture causes the current to begin to short circuit around the inside of the walls. The larger the air space inside of the muffler the longer it will run without having to be cleaned.

The less painful nature of the contractions evoked by the static condenser discharge, the lack of trauma, the thoroughness with which *all* contractile tissue is affected and the perfect decongesting action of this discharge all combine to make it much to be preferred over manual massage or "stripping" in that class of prostatitis characterized by congestion, "bogginess," etc. It is much better than low tension surging or waves

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Fig. 29.—Hookup for direct sparks. Patient on platform connected to negative pole. Positive pole is grounded. Spark ball is grounded to same or separate ground. Leyden jars are not connected up.

from low voltage outfits. The static condenser discharge alone will clear up some of the early congestions and we have noted in more than a few cases the disappearance of pronounced melancholic symptoms along with the clearing of the congestion in middle aged patients where diathermia and static were used. It should not be used with any hope of a "cure" in advanced fibrotic conditions or so-called third lobe cases. It is too late for the static alone in these cases. Nature has resorted to a massive fibrosis. Here we must resort to the treatment for fibrotic conditions elsewhere; diathermia with the sedative, absorptive technic, the static for its mechanical contractive effects, ultraviolet and the x-ray for the chemical and absorptive effects. This sequence will often give a great measure of comfort and relief of symptoms even in these advanced cases where operation is contraindicated or refused. The condenser discharge should not be used in gonorrheal prostatitis for obvious reasons, at least not until after a course of diathermia and ultraviolet light. Like massage, the condenser discharge should not be used in the presence of malignancy or tuberculous lesions. To sum up its place in physiotherapy in one sentence, it may be said that it occupies a place well in advance of any other mechanical decongesting agency.

Direct Sparks.—In this, as in all other static modalities except the effluve, a hookup is used that differs from the commonly taught and accepted way. The action of sparks upon the tissues they strike is exactly analogous to that produced under a static condenser electrode except that the density of current in the case of the spark is many times greater than on the condenser electrode, because the whole capacity of the machine (when not modified by interposing resistance as in the case of indirect sparks) is concentrated to a very small area. Because of this concentration, the action on the tissues is much more intense, much more localized, but also much more painful. The burning, stinging sensation on the skin and the intense localized concentration which takes place in the tissues directly under the spark makes it impossible to repeat the application time after time in the same place as is done in the case of the wave, so the application must be labile instead of stabile.

In the case of the static condenser discharge the active electrode is positive because trial convinced the first user, as it has every experienced user of static electricity since, that thus used the contractions induced were much more intense and efficient than when the negative pole was used. In the giving of sparks the active electrode is the spark ball and to have it positive the patient must be attached to the negative pole of the machine. If you attach the patient to the positive pole then the active electrode—the spark ball—is of negative polarity and you are reducing the efficiency of the application. A glance at the hookups will show that the connection for the direct spark and the blue pencil effluve is exactly alike, the only difference in the method of applying the current being that in the case of the De Kraft electrode a high resistance in the electrode and the absence of any storage capacity gives a smooth, non-disruptive flow of current through the air gap between the electrode and patient while the high resistance of the effluve electrode prevents a disruptive discharge across the ionized air gap such as would occur from a spark ball.

Were the spark ball to be held steadily at a distance from the patient that would allow a constant stream of sparks to cross to the patient, each spark would have less mass to it than when the current is compelled to accumulate by moving the spark ball away from the patient and increasing the resistance of the air gap to a point where sparks will not pass, and in addition to being less efficient, the rapid succession of sparks would produce unbearable pain. This is the reason for swinging the spark ball to and from the patient in such a manner that only one spark passes at each swing—to have more mass to each spark and to cause each succeeding spark to strike upon a different skin area. Taking the hydro analogy again the different effects of effluve and the spark could be roughly compared to having an extremely high pressure stream of water nebulized and sprayed over a rather large area constantly or to having the same amount of water, under the same pressure, condensed to a very small ball and shot against the skin where the energy of the discharge would be concentrated upon a fraction of one per cent of the area covered by the spray.

Perhaps I can illustrate the effect of sparking an inflammatory area better by the following comparison. In certain parts of the country occur tracts of ground known as "hard-pan" farms. At some time in the past water carrying a sediment of clay and black loam has overflowed this land and deposited a layer of earth over the surface. The clay, being heavier, settled first and the lighter loam covered it to a depth of several inches. Later the stream responsible for the deposit changes its channel and the land is left high and dry. The land is cultivated, crops sown and in a very short time, due to the richness of the top soil, a profuse growth of grain breaks through the top and grows rapidly. Only the circumstance that the moisture necessary for its growth comes from above and not below the clay enables it to grow at all. Rain, falling, enters the soil, goes down until it strikes the clay and either follows this to a natural drain or is held and evaporated by the heat from the sun in a day or two. The result is that by the time the grain has reached a size that demands considerable moisture for its growth it is unable to obtain this moisture and it becomes stunted. It never grows to anything like normal size and the ears of corn or heads of wheat do not fill, only an occasional grain appearing instead of row upon row, the growing grain stalk takes on a sickly hue and by the time it should have reached maturity it is not worth the labor and expense of harvesting. Such ground naturally is almost worthless. Along comes a professional "hard-panner," explains matters to the farmer, and makes a contract for so much an acre to make the ground productive. He goes over the field, drills holes at regular intervals, places a small stick of dynamite into each hole, connects them up with his battery and detonates or explodes them. The next and succeeding crops are record breakers. What has he done to secure this astounding result? Simply restored circulation; made it possible for the rainfall to enter the ground and for the roots of the plants to go down and draw it back as needed. The exudate left after an inflammatory reaction acts almost like the clay—shuts off circulation, produces pain and lack of function and, if not removed, organizes and does still further damage. Static sparks act upon recent exudate in much the same manner that the min-

ute charges of dynamite acted upon the clay shell, shatter it and cause its absorption and removal. With the interference to circulation removed, the pain (pressure and interference with nutrition) is relieved, musculature contracted from irritation or for protective purposes relaxes and resolution proceeds.

Static sparks formerly occupied a very much larger place in our work than in the last several years as we now use conversive heat (diathermia) in many places where we formerly made use of sparks, but we still find them of great use in acute strain, arthritis—especially spinal—and in places difficult to reach with massage or where the more diffuse effects of the condenser discharge are not violent enough to break up adhesions or fibrosis. A compromise between the condenser where given as usual with a fairly large metal electrode and spark effect can be secured by attaching a spark ball, (electrode with ball about an inch in diameter) to the positive pole (use exactly the same hookup as in the condenser discharge—in fact this is a labile, concentrated condenser discharge) and placing the ball in contact with the skin and the muscles around a joint (shoulder girdle, for instance) regulating the strength by the spark distance across main terminals and sliding the ball to a slightly different spot between each discharge. This is, naturally, very painful but it is very efficient in breaking up adhesions and fibrosis such as occur around primitive dislocations.

Sparks can be placed more accurately by ''peeking'' at the point a spark is desired with the spark ball than by using the broad, swinging curve. The electrode should be handled much as a hammer is used in striking a nail head except that the blow is stopped short and the spark ball rapidly jerked back from the surface as soon as a spark crosses to the patient. If you wish to place sparks in between bony points (a bony point should never be struck with a spark because it is intensely painful and serves no good purpose) or in rather inaccessible parts where projecting anatomical points catch the spark, a spark director can be used. A serviceable one can be made in a few minutes by taking a two foot length of wooden rod, drilling a hole through it near one end at right angles to the shaft, and inserting a long finishing nail or other nail with a small head. Smooth

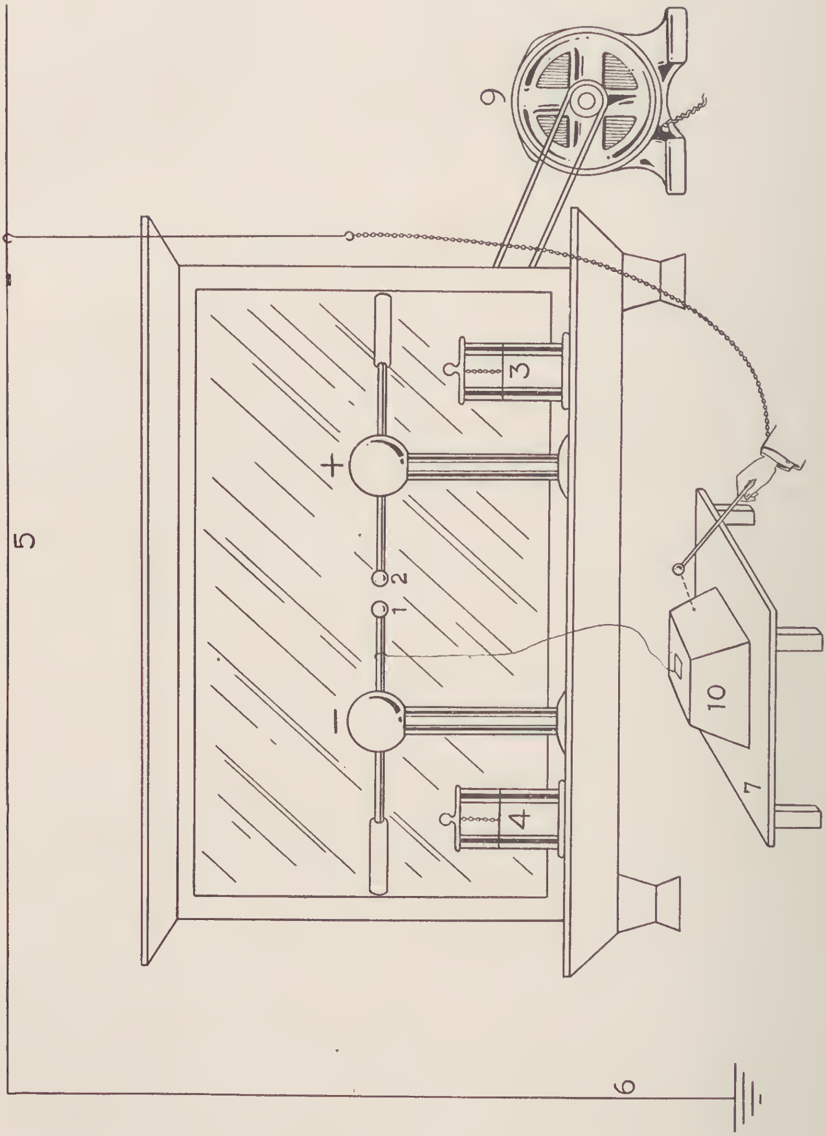

Fig. 30. (For description, see pages 136 and 149.)

this nail head up if it is rough, place the nail head on the spot you wish to have a spark, holding the director back towards the end of the handle and deliver the spark to the projecting end of the nail.

The intensity of sparks can be varied in several ways. Speeding up the plates increases and slowing down diminishes their mass; using the indirect hookup (by cutting in the resistance of the machine legs, floor and wall up to the ground wire) lessens the force; placing the machine connection to the patient at a remote corner of the platform lessens; leaking off a part of the platform charge by resting one foot of the operator (to avoid shock keep the foot away from any part of the patient or the connection to the machine) or part of the current can be grounded or wasted by sliding the main terminal balls near enough to each other that part of the current crosses. The main terminals may be used as a safety gap if desired, setting them at the distance of the maximum spark desired. Sparks to patient will always be of less length than this distance. If a heavier spark is desired than results when the direct spark hookup is used, put on and connect up the leyden jars as for the condenser discharge.

This latter spark is a great cure for that rather troublesome class of malingerers complaining of "misery" in the back. (Oh, for a true miserometer!) We give them every treatment until we ourselves are in doubt as to whether they do or do not have this pain, and then we tune up "Josephine" (the largest static) and introduce them to the leyden jar spark cure. If they really have a severe pain they gain relief and take to subsequent treatments kindly, but if they do not have it you want to stand by for squally weather when you suggest that they continue the treatment several days or weeks. Some few people simply cannot take sparks and it would not be fair to classify these as malingerers, so I always lead up to the treatment by easy stages to test their tolerance first. Unless the patient really has a bad pain the game is not worth while to him when he reaches this stage,

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Fig. 30.—Hookup for indirect sparks. Patient on platform to negative pole. Spark ball is grounded. Positive side of machine is not grounded and the leyden jars are not attached or connected in any way.

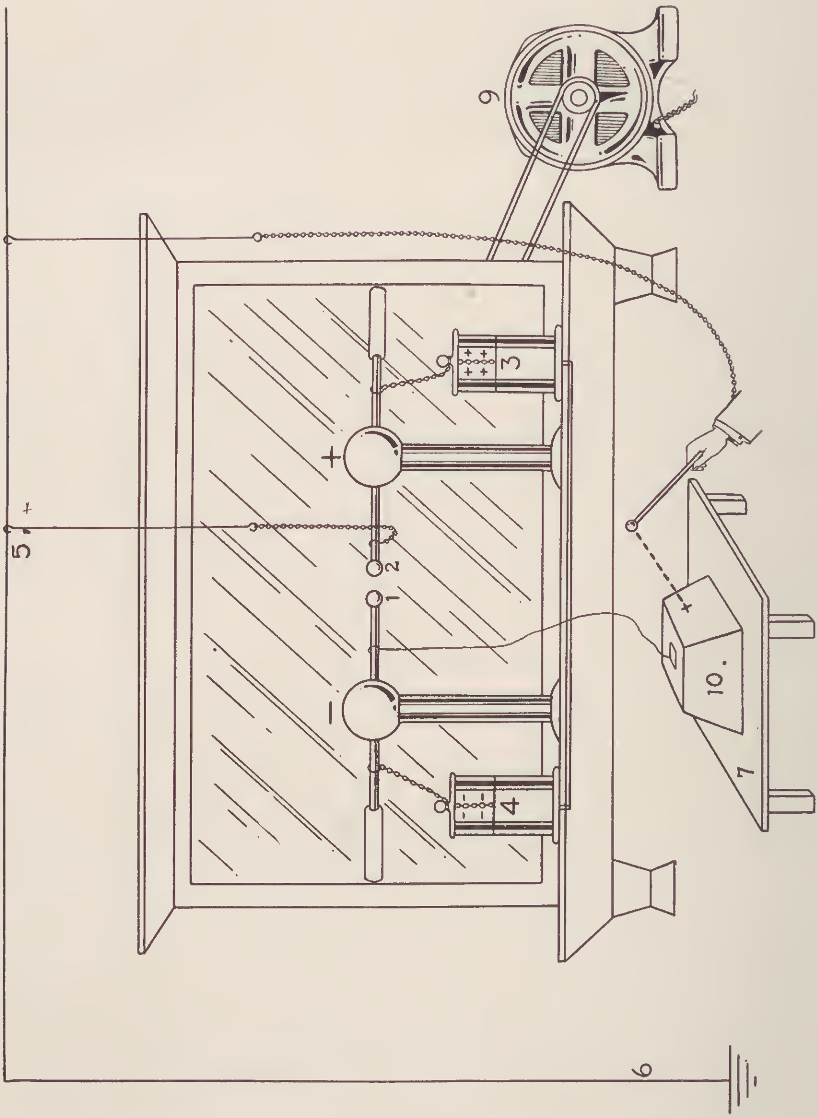

Fig. 31. (For description, see pages 149 and 151.)

and he either recovers suddenly or shows fight. His actions and hang dog look give him away in either case. I have had a malingerer who saw that his game was up become so furious that he actually attacked me while I was personally treating him. He later unblushingly admitted that he had been shamming all the time and had been in several hospitals.

The Static Effluve.—Formerly the static brush discharge as it was called was administered through a green stick or through moist pencil-shaped pieces of wood, but no two treatments were ever the same. The moisture evaporated or the heat from the passage of the current dried them out and it was an art to keep a supply of these wooden electrodes near enough to the efficient working point to use them when needed. Various glycerin and other electrodes were devised but it remained for Dr. Frederick De Kraft of New York City to invent the most practical substitute. His electrode is a long, pencil-shaped tube of rubber or fiber filled with an asbestos composition and capped on one end with a ring for attaching the ground wire and a small pointed piece of brass or copper on the active end. This electrode will give many months or years of continuous service before it finally acquires too high a resistance for good work and can then be refilled at the factory. The effluve from this electrode varies with the power of the machine, atmospheric conditions, etc., but until it is worn out will give good service. When the machine is working properly a very fine, purplish or violet effluve is visible extending from the end of the electrode to the skin. The area of skin covered varies but the intensity is greatest in the center of a circle on the skin forming the base of a cone the apex of which is the point of the electrode.

Start into full operation with the hookup given and approach the point of the electrode to within from four to fourteen inches

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Fig. 31.—Hookup for the extremely heavy leyden jar direct sparks. This hookup will give the most massive spark that a given machine can be made to deliver. Patient on platform to negative pole. Positive pole grounded. Spark ball grounded to same or separate ground. Leyden jars attached each to its own pole and the bases connected across as in the condenser discharge treatment. These sparks are very painful and are for use only where deep effects are desired. When being used every precaution against the accidental discharge of one or more of these heavy sparks to some area not under treatment should be taken. All swinging connections must be held away from surfaces and only the spark ball itself ever allowed to approach any part where a spark might occur.

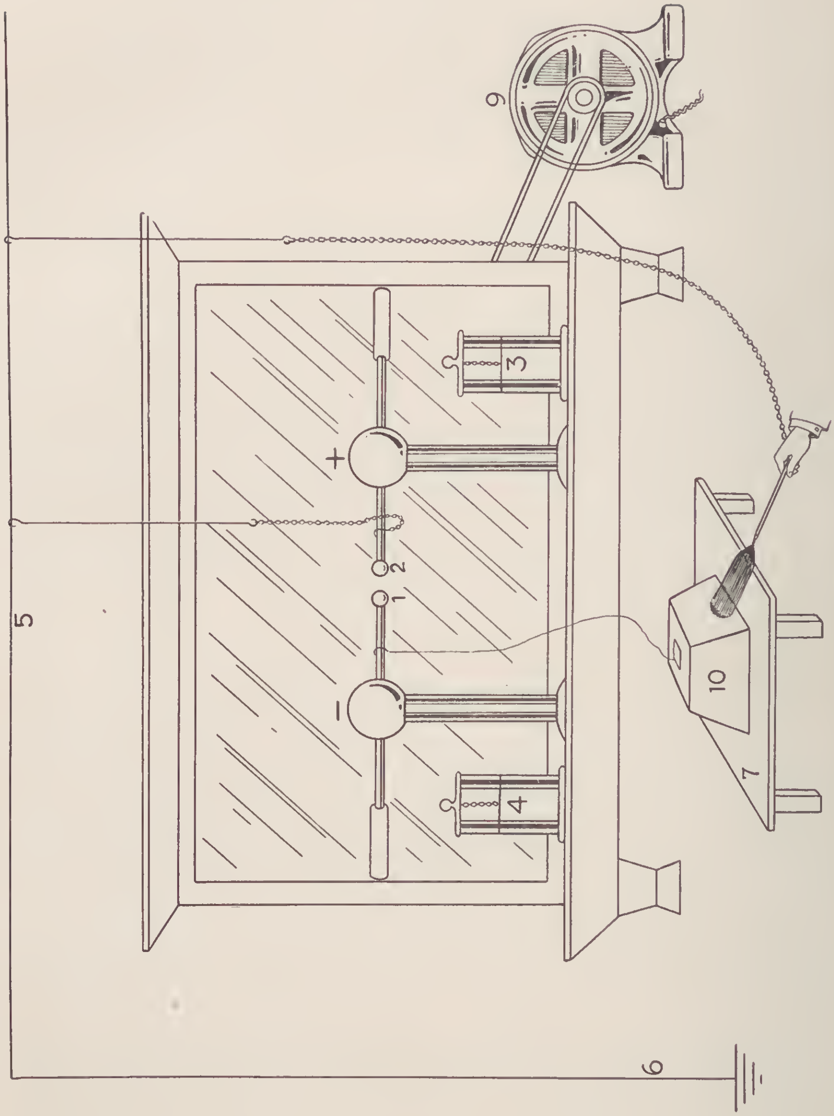

Fig. 32. (For description, see pages 151 and 153.)

of the patient. If you approach too near the effluve takes the form of a small bright stream instead of a large feathery purple or violet effluve, a hissing noise is audible and the discharge is stinging in character instead of sedative as it should be. The best efficiency is obtained when this point has been found and the blue pencil pulled away from the area an inch or two further until the discharge assumes the purple, feathery character. It is used for sedation, superficial decongesting effects, etc.

If this effluve is played over the closed eyes and on the face underneath them for some twenty minutes before the extravasated blood and lymph have had time to coagulate, it will obviate the patient's need for that distressingly simple, common, and sometimes true, explanation that he "ran into the edge of a door." I have treated football players who had sustained a badly broken nose and whose black eyes were beginning to show up, and the next day the only thing that showed was a dark line along the cartilages of the lids, only showing upon close inspection and appearing as though they had slightly overpenciled their lashes. If the blood has already coagulated when the patient appears, diathermia over the discolored area followed with a strong blue pencil effluve will markedly hasten the clearing up process. This effluve will cut short an acute paroxysm of bronchial asthma in one or two minutes if played over the face, neck, and upper chest. It is only slightly curative but it certainly is palliative. It will relieve the pain of zoster rapidly. I formerly used the brush discharge and later this blue pencil effluve in the treatment of indolent ulcers, granulating wounds, etc., but for several years now I have secured better results in these conditions with the quartz mercury ultraviolet. The effluve played over a surface which has just been liberally sparked will remove most of the sting caused by the sparks. A sick headache is sometimes almost instantly relieved by the effluve, but if the headache is from indigestion it probably will be made worse. I have repeatedly had this experience, some of the patients vomiting before they could get off the static platform, the vomitus

Fig. 32.—Static effluve through the De Kraft blue pencil electrode. Patient on platform to negative pole. Positive pole grounded. Blue pencil electrode grounded. Leyden jars are off.

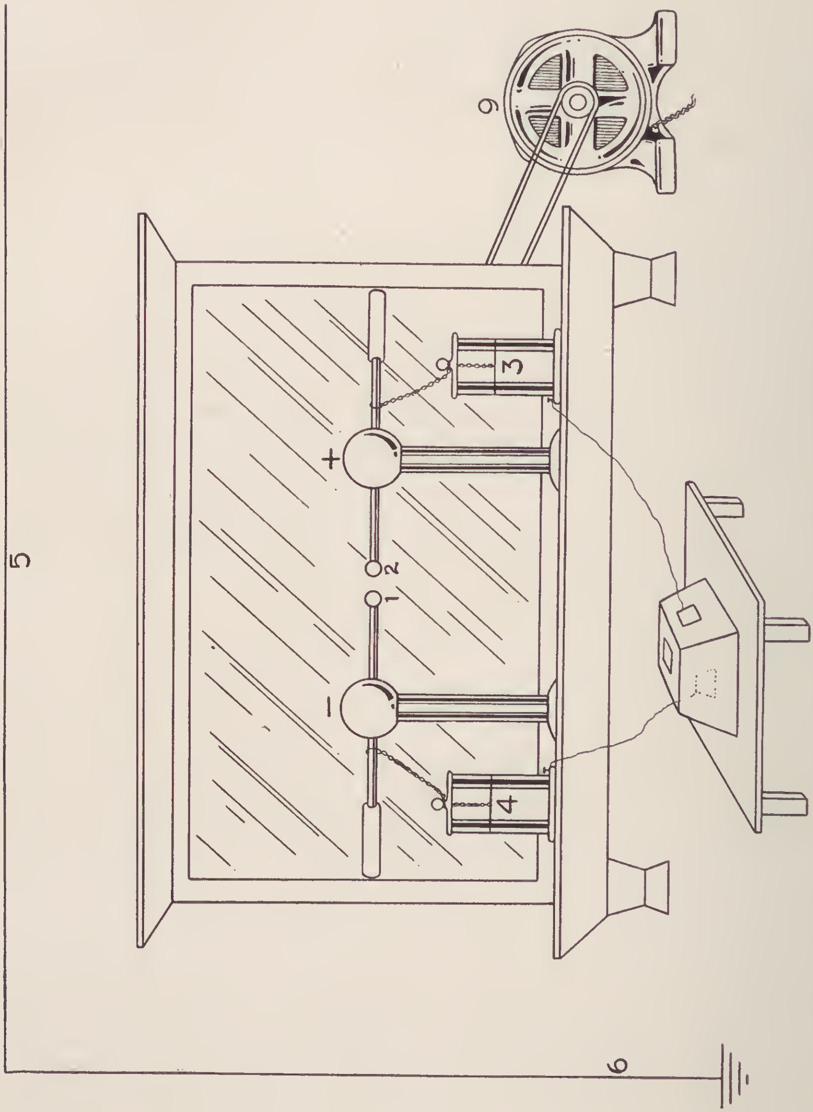

Fig. 33. (For description, see page 155.)

being almost projectile in character. If attempt is made to use the brush discharge or effluve with the wrong polarity the discharge is sputtering, irritating, and has not the violet color of the sedative effluve.

Static Induced.—Care must be used in starting these bipolar static treatments. The contractions induced under the electrodes are of tremendous vigor and the main terminals should always be closed before starting the treatment and should be opened very slowly and cautiously. To appreciate the force of these contractions the physician should place one of the electrodes on his own abdomen, the other on his back and have someone give him a treatment. The sensation—when the poles are very much separated—is one of terrific compression. With a large machine and multiple electrodes, it is one of the best methods of treating obesity. Too long treatments should not be given until the ability of the patient's system to eliminate the combustion products is tested. I have had one case of acidosis follow an overtreatment and have noted toxic symptoms in others. I prefer the static induced to the Bergonié chair in the treatment of obesity. About the only other use I have made of this current is in treating constipation. Here we place a stationary electrode low on the back and slowly move the abdominal electrode (asbestos or felt, well soaped) over the intestines.

Static Saturation.—(Variously called static electrification, static bath, static charge, static insulation, etc.) This method of treatment consists simply in charging a patient to full saturation and prolonging the charge for from ten to twenty minutes. Have the patient seated so that if he should go to sleep (they very often do) during the treatment he will not fall off the chair or platform. The method of connecting the patient to the machine is immaterial as he will charge from a connection made at any

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Fig. 33.—Hookup for the static induced. This is a bipolar treatment and the patient need not be upon the insulated platform unless desired. The leyden jars are connected to their respective poles but are not connected to each other across the base. Neither side of the static is grounded. One of the electrodes on the patient is connected to the outside coating of the leyden jar on that side and the other is connected to the outside coating of the other leyden jar. The main terminals are closed at the start and are to be opened up very carefully and slowly until the tolerance of the patient is reached.

point. It is better to have his bare feet upon a metal plate connected to the machine or to have an electrode under him on the chair or under his back if a reclining chair is used as if he holds a handle in his hand he will almost surely drop it when he begins to drowse or loosen his hold on it when the current will sting his hands.

It is a good application in nervous insomnia, neurasthenia and conditions where low blood pressure is a factor and has a stimulating effect upon the skin, increases excretory processes, especially of kidneys, and in common with static sparks to spine will raise subnormal blood pressure. I formerly used it routinely as a tonic measure in pulmonary tuberculosis, arthritis and metabolic disorders, but in later years we seldom use it except upon neurasthenics and now rely upon general high frequency and the ultraviolet light in many of the conditions where I formerly used it. There is no question as to its value, but we had unlimited high frequency and ultraviolet machines which would take care of its tonic and metabolism effects, but which would not give us the sparks, wave and effluve of the static. Incidentally, we have heard of many ways to get "better than static sparks, wave, effluve, etc.," with some outfit other than a static machine. Investigation, so far, has always shown that somebody was mistaken and from the line of talk some of them advance it would appear that they really know very little about static and figure that others know less. The static operator who has a good machine, knows how to use it and not abuse it, is going to require a good deal of "showing" before he will trade it for any substitute. In fact I am positive that unless the inventor of the better substitute is so jealous of his invention that he is keeping it strictly under cover that there is no such thing extant. If the static had no other field than as an adjunct follow-up to diathermia it still would have an indispensable place in any physiotherapy office or clinic. A fibrosed joint or certain adherent scars may be manipulated to a point that, without static to remove the acute strain produced, it would be impossible to touch it again for over a week and it would be in worse condition than ever then on account of the additional trauma, and by

following the forcible manipulations with static practically every trace of soreness may be removed and these intensified treatments repeated daily.

Some years ago Dr. D. H. Yates, of Madison, Florida, reported some cases of deafness treated by means of static electricity. His hookup was as follows: Patient on platform. Spark ball electrode moistened, hitched to negative pole of static and placed against the deaf ear. A multiple point metal static electrode is attached to the positive pole and either held by hand or placed in the clamp of a tube stand and approached to within two and a half to three inches of the other ear, care being taken to keep the electrode at such an angle that all points on it are equidistant from the ear. The static machine is not grounded and the leyden jars are disconnected, main terminals opened wide. Time of treatment thirty minutes from twice daily if possible to once on alternating days where more frequent treatments are not possible. I tried this method on a number of chronic catarrhal deafness cases. Some of the more frankly catarrhal cases made remarkable improvement after a few weeks daily treatment, some made only a slight improvement and some no visible improvement.

All patients objected seriously to the sparking which, in spite of the most careful control of electrode distance, speed of machine, etc., occurred quite frequently. These sparks will occur between the electrode and the ear or side of head at the least movement of the patient and frequently without any movement on the part of the patient. A constant breeze, sometimes intensified to actual passage of sparks, occurs between electrode and shoulder and quite often the skin of the ear under the spark ball electrode will blister. A result was that fully half the patients—more than half among women and children—refused to take the treatment more than a time or two. This caused me to cast around for some method of getting the current through the ears without the disagreeable features if possible and after considerable study and experimentation, I modified this technic in several particulars. First, to eliminate the blistering, I concentrated the current exactly where it was

wanted and thus made an equal amount of current more effective or a lesser amount equally effective. I took a small mass of salt-solution saturated cotton, twisted one end of it to a size that would allow it to be inserted into the external auditory canal, inserted it as far as possible, spread the outer end to fill the external ear and laid the ball point electrode against the wet cotton. (The patient holds this electrode by the rubber handle during the treatment in such a manner that all parts of the metal are kept away from the body except the contact end.) Then in the other ear, the same thing was done except that here the cotton was twisted to a point on *both* ends, one twisted end being applied in the auditory canal, the central mass of cotton fitted into the external ear in such a way as to hold it there during the treatment and the outer twisted end (usually about two inches long) projecting outward, and *slightly downward.* This downward slope to the outer end is very important as, if it is not slanted so that gravity pulls the water down into the end the concentration of current on this end for twenty or thirty minutes will gradually dry the end of cotton and might even, near the end of the treatment, set it on fire. I have never seen this occur, but it is a possibility. Thus a path of low resistance has been furnished for the current through the bony skull on either side and it has been concentrated entirely through the middle ears. Then the De Kraft blue pencil is substituted for the multiple point electrode, it is *grounded* as is, also, the positive pole of the static.

The main terminals are opened full open, the machine started into full operation and the effluve electrode point approached to within proper distance to secure a full, feathery effluve. If it is brought too close, the purple effluve will give way to a hissing stream and the patient will complain or move away. The blue pencil can be fixed in a clamp as was the other electrode or if the operator wishes to hold it during the treatment a very good way of resting the arm and making the treatment much less tiring to the operator is to take a long mop handle, curtain pole or similar thing, tie a loop of cloth to the upper end, rest the lower end on the floor in front of the operator's feet, insert

the forearm of the operator holding the effluve electrode through the loop and proceed. I have found this modified technic fully equal in effect, if not superior, to the original technic brought out by Dr. Yates and all the original objections are overcome. With this technic it makes very little difference which ear is turned to the effluve electrode as the density of current is almost exactly equal on the two sides, but I routinely place the most affected ear next to the blue pencil. If loose hair on a female patient persists in flying out into the effluve a turn or two of bandage around the head above the ears will stop it.

This method of treating chronic catarrhal deafness will give results in a sufficiently large percentage of cases to justify its trial in all of them. In the case of pustular otitis media we would be inclined to defer its use until the discharge had been cleared up by radiant light and heat and ultraviolet, indirect diathermia and ultraviolet (the *ultraviolet* being given generally as well as locally as in all pus formation cases), local treatment or other means. This treatment can be combined to advantage with vibration applied to the bone around the ear, to the points of the jaw; with the Stoke's x-ray treatment; with the surging *negative* galvanic current to the ear, etc. Its principal action is decongesting and a very delicate vibratory shaking up of the tissue cells in its path.

CHAPTER X

ACTINOTHERAPY

General Considerations.—One of the most intensely interesting things in the whole field of physiotherapy is actinotherapy or the use of the actinic ray, more commonly known as the ultraviolet ray. The results following the proper use of the ultraviolet ray are so prompt and positive, the range of its indications so large and diversified, due to its peculiar adaptability to being used either as a local or as a general remedy or both in the same case, its faculty of being available for use as the primary remedy or to being used to intensify very markedly the reaction from some other remedy as well as its paradoxical adjuvant and antidotal action when used with small and large x-ray dosage in therapy, all combine to make it indispensable to the physiotherapist and almost so to any therapist. With no other remedy, medical, surgical or physical, can dermatoplasia be favorably influenced so positively, quickly or safely, and the same might almost be said of its action upon blood chemistry. To appreciate exactly and in full what this statement means one must actually have used it on literally hundreds and thousands of cases and have checked it closely clinically, in the various laboratories and with painstaking research. In no other way could you be prepared to accept certain very true statements that might be made and which would be received with total incredulity otherwise. To substantiate the foregoing statement would require such a mass of case histories, laboratory findings, researches, illustrative photos and explanatory detail, some of which are to hand and some of the latter not yet worked out that that, alone, would make a volume far larger than the present work can be made and still have it practical.

As each improvement in ultraviolet apparatus comes out we find some new thing in clinical results still further to stimulate our efforts and send us a little nearer to nervous prostration from the pernicious habit of using our waking hours trying to

improve technic and secure still better clinical results and using our sleeping hours trying to puzzle out an explanation that really will explain. When we consider the fact that, despite the tremendous amount of research that has been done and the progress that has been made in attempting to solve the riddle of why and how, exactly, certain constitutional effects follow certain dosages of the x-ray, the answer has not yet been arrived at, we are inclined to be pessimistic as to our ability to solve this apparently complicated constitutional reaction of ultraviolet and to leave the attempt to do so to some institution or persons better fitted for the task both mentally and financially. The radio-active substance research field is one of limitless possibilities and is most intensely interesting. The clinical application of radiant energy is no less fascinating.

I strongly recommend to the student of ultraviolet light therapy that he purchase ''Principles of General Physiology'' by W. M. Bayliss (Longmans, Green & Co.) and study and re-study not only the section on the action of light but the entire work. The bibliography list of the Leonard Research Prize Thesis (p. 258) offers much good material for study, especially the article by Clark on the Action of Light on the Leucocyte Count; books on Actinotherapy may be had and current scientific journals are sure to have more and more articles on the subject in them as interest in, and the use of, ultraviolet light grows. It should hardly be necessary to add that just because an article, statement, or set of statistics does appear in some magazine or other print that that in itself is no valid reason for accepting it as law and gospel. Weigh all such statements, printed or spoken, carefully before accepting them even for trial. We cannot afford to be less critical than the surgeon or other specialist who insists upon knowing the experience of the man submitting new technics before they take him seriously.

THE ACTINIC RAY

The actinic ray is better known as the ultraviolet ray. It is called the actinic ray because it has the power to excite chemic action and has more effect upon photo sensitive paper than

other light rays and is called ultraviolet because it lies just beyond the violet of the visible spectrum. It is an invisible ray, just as much so as the x-ray. What you *see* when you look at a lighted quartz mercury burner is not the ultraviolet ray but the violet, indigo, blue, yellow and some of the other *visible* rays. As in all other fields, to get at some definite standard for comparison, an arbitrary unit of measurement is adapted. This unit in the measurement of light wave length—visible and invisible—has been named the Angström unit. An Angström unit is a unit of wave length measurement and is one ten-millionth of a millimeter in length or, approximately, one ten-millionth of the thickness of a worn dime It is very hard for the human mind to form an adequate conception of such an extremely short unit but science has no difficulty in measuring it, even measuring small fractions of one of these single units. Starting with the shortest wave length at present known, the hardest gamma rays of radium, we find that these gamma rays have a wave length of from two to seven hundredths of one Angström unit. Then come the harder x-rays with a wave length of a very few Angström units, one or less to eight or ten. Then comes a section of the invisible ray field as yet uncharted until we reach the beginning of the extreme ultraviolet field. Until quite recently this uncharted field extended down to about nine hundred Angström units but recent work by Millikau has pushed the limit on up to about three hundred and sixty A°. Schumann, Lyman and others have done much research work in charting this unknown field. (The terms "up" and "down" refer to the vibratory frequency of the wave and not to its Angström unit wave length. The shorter the wave length the more rapid its vibratory frequency. See spectrum photograph.) The extreme ultraviolet field extends from the shortest ultraviolet yet measured—about 360 A°.—down to a little beyond the limit of quartz transmission, or to about 2000 A°. (Quartz will transmit only up to 1849 A°. Shorter wave lengths are absorbed by quartz.) From about 2000 A°. to 3000 A°. is called the far ultraviolet and from 3000 A°. to about 4000 A°. is the near ultraviolet. Below this comes the visible ray spectrum ranging from violet on the shorter

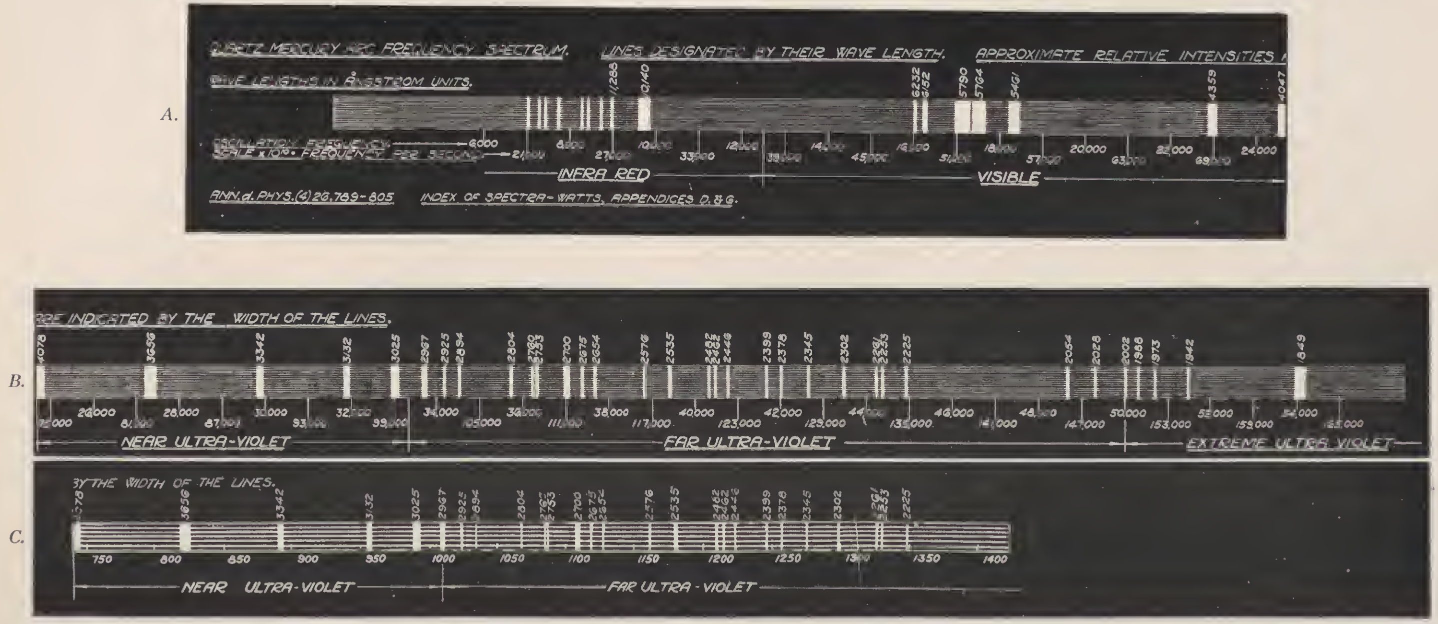

Fig. 34.—Visible and invisible spectrum photographs. *A* has been cut at *B*. *B* and *C* show the comparison between the older types of ultraviolet generators and the new ones. *B* is the spectrum of the new quartz-mercury generators. Note how much farther its spectrum extends (into the extreme ultraviolet section) than does that of the older type of lamp and note also the great intensity of the rays at 1849 A°—greater intensity than at any other point in the ultraviolet section.

wave length end to the red rays, the longest of the visible rays. Beyond these visible red rays come the longer wave lengths, ultra-red (invisible), heat waves, etc., down to the Hertzian waves, from a few centimeters to hundreds and thousands of meters in length.

Some writers on ultraviolet give the various wave length sections slightly different names. Instead of calling the divisions the near ultraviolet, the far ultraviolet and the extreme ultraviolet, they name them the ultraviolet, the ultra-ultraviolet and Schumann's or Lyman's band. These are synonymous sets of names and one set of division names seems to be used about as much as the other. They are only mentioned to avoid confusion in the minds of students learning under one terminology and later reading an article by an author who uses the other. Occasionally an author, instead of using the Angström unit, will use the millimicron ($\mu\mu$). If the derivation of the word is borne in mind no confusion need result. A micron is one millionth, a milli one one-thousandth, therefore a millimicron is one millionth of a thousandth of a meter or *one billionth* of a meter. An Angström unit is 1/10,000,000 of a millimeter in length which is 1/10,000,000 of a thousandth of a meter or *one ten billionth* of a meter, therefore a millimicron equals ten Angström units. It is only necessary to convert millimicrons to Angström units to multiply by ten or add one cipher, conversely, to convert Angström units to millimicrons to divide by ten or place a decimal before the last figure. Thus a wave length of 390 millimicrons would measure 3900 Angström units. Forty-five hundred Angström units would equal four hundred and fifty millimicrons (450 $\mu\mu$), etc.

The ultraviolet generating apparatus has gone through about the same evolutionary stages as the x-ray. It is a far cry from the first static or interrupter type x-ray outfit with its very limited capacity, its noise, gases, uncertain interrupters, its temperamental gas tube and its many other faults, to the modern interrupterless transformer and Coolidge tube outfits, capable of answering any reasonable demand made upon them and standardized to a point where almost any operator with a good outfit

and technic can duplicate results consistently. The first arc lamp ultraviolet light outfits were cumbersome, noisy, dangerous at times, and gave limited quantities of the actinic ray of the longer wave lengths. Much credit should be given Finsen, Rolier, and others for the good results they obtained with even these crude outfits.

As time went on different substances were mixed with the carbon electrodes of the arcs (the so-called "effect coals" of the Germans) until it was found that tungsten gave an exceedingly rich ultraviolet. The quantity was much improved, but the quality remained about the same—the wave lengths of the actinic ray given off from these arc lamps were all of the longer lengths. Then came the Cooper-Hewitt mercury vapor tubes, but because of the fact that all of the ultraviolet ray was absorbed by the glass tubes except a very little of the very longest wave lengths, this lamp was only used commercially. Then came the quartz mercury arc which was a great improvement upon all previous types of actinic ray generators. Quartz is used in the generator or burner of the ultraviolet lamp for two main reasons: because it transmits or is transparent to ultraviolet of all wave lengths up to 1849 Angström units, whereas glass is opaque to all ultraviolet except the very longest wave lengths and because the conditions necessary in the generation of large quantities of the actinic ray of the medium and shorter wave lengths causes the generator to reach a very high temperature. Quartz has almost exactly twice as high a melting or fusing point as the best glass, and glass would quickly melt or fuse at the temperature reached in the quartz mercury arc. Fluorospar is even better than quartz, but at present, on account of the difficulty in securing or working it, it is not used. Much work is now being done with a view to improving the design of present burners or securing a more efficient type, and improvements will undoubtedly result. The present renewal prices charged for burners are an imposition upon the medical profession, and this holds for *all* types of burners. These burners should be sold under a guarantee of at least 2000 hours and replacements made under the same conditions as are adopted by the makers of automobile tires. Until

the manufacturers of ultraviolet ray apparatus have the good sense to see and recognize this fact, the use of the lamps is going to be more or less restricted. At the prices charged—and these prices are not too high if service were guaranteed—the physician has a right to some sort of a service guarantee.

At the present time there are two distinct types of quartz mercury generators on the market. The mercury anode type almost uniformly gives long service but, up to a very few months ago, did not compare with the tungsten anode in the *quality* of ray generated. It is unfortunate that the tungsten anode lamp—which gives a very fine quality of ultraviolet ray—is so fragile and breaks the burner (generator) so easily. Recent instructions sent out by the vendors of the tungsten anode quartz lamp to users of their water-cooled lamps to cut the operating voltage down very markedly will probably result in a lessened number of broken burners, but it will also result in markedly decreasing the clinical efficiency of the lamps as well.

The makers of the mercury anode lamp have been working hard, since users of the tungsten anode demonstrated the increased clinical efficiency of that type of burner, to improve the mercury anode type and in the spring of 1922 gave us three of the newer models to try out. These new models were very much better than the older models and were of approximately the same intensity as the tungsten anode type of burner. We hope that the competition continues and that still more improvement on both types results.

It has been definitely proved by Bayliss, Clark and others that the shorter wave lengths of ultraviolet are more soluble in protoplasm, more bactericidal and are the ones which produce a leucocytosis. Our clinical results over a period of years and in an extremely wide variety of cases confirm these observations. The shorter rays are more clinically active rays and a local reaction secured by the use of the longer rays while it may look very much like a similar degree reaction secured by the use of the shorter rays, in reality it is a different matter entirely. In addition, by the use of the shorter rays, reaction may be secured in certain atrophic conditions where no reaction would

follow the use of the longer rays and in *any* tissue the reaction can be carried much further with the shorter rays than would be possible with the longer rays. And this *intensity* of reaction is a vital factor essential to success in some of the more stubborn pathologic conditions.

Right here we think it germane to insert a caution. The man who starts into actinotherapy with the idea that it is an exceedingly dangerous remedy and that "burns"' must be avoided at any cost is going to fail in all except the easiest cases. The man who uses the term "burn" to describe *any intensity* of reaction from the use of ultraviolet is making a sad mistake. The profession and public (and the damage suit lawyer) are very familiar with the term "x-ray burn" and picture it as some awful, incurable condition, leading to loss of limb and life (often true, formerly) and, if given the least chance, will place the very beneficial reaction following intensive actinotherapy in the same category. Use the expression actinic erythema, erythema solare or dermatitis, specifying the degree, first, second, third or fourth if you must, but never make the mistake of referring to it as a "burn." It is *not* a burn. In fact, the very best treatment for *any kind of a burn* from "x-ray burn" through the heat and chemical burns to sunburn is *properly administered* actinotherapy. The worst result that can possibly follow an overdose of the actinic ray from an air-cooled lamp is a blister and a feeling of malaise or lassitude for a few hours or a day or two. Two hours continuous exposure to the most intense air-cooled ultraviolet lamp at a proper treatment distance will not destroy the skin; it will only blister. It *must be understood* that an air-cooled ultraviolet burner reaches a high degree of heat—becomes incandescent in fact—and if such an incandescent body be brought close enough to the skin and held there long enough a bad burn and slough will result, but such burn in such circumstances is *not an actinic ray product* but simply a heat burn. If any other incandescent body of the same size and temperature be approached to the skin to the same distance and held there for the same length of time the same degree of burn would result although no ultraviolet at all were being given off by the heated body.

The ultraviolet ray itself has no heat. It is sometimes referred to as the cold ray. It is clear across the visible spectrum from the heat rays. The sensation of heat felt by a patient under the ultraviolet lamp *is* heat; heat from the relatively small quantity of heat rays given off by the burner because of its high temperature. Filter the heat rays out and the ultraviolet ray itself would produce no sensation of warmth. For this reason it is not wise to approach an air-cooled burner closer than seven or eight inches to the skin, for any except the briefest exposures. With the water-cooled burner the case is different. Here the burner is cooled by a layer of water circulating around it and is less than an inch from the skin when applied in contact or under pressure. Being cooled by water, it is not dangerous at this near distance unless heavy overexposure *under pressure* is given and even then the destruction that takes place is superficial compared to that following the application of heat or chemicals in quantity sufficient to destroy tissues. A burn in such circumstances is also a heat burn, the compressed tissues not being allowed to protect themselves by flushing the parts with blood to carry the heat away and the heat slowly accumulating to the destructive density point.

Ultraviolet, especially the shorter wave lengths, is practically perfectly soluble in the blood and no ultraviolet of any intensity yet developed will penetrate more than one or two millimeters of thickness of blood. It is for this reason that pressure must be used—to dehematize the tissues—when a reaction that will extend deeper than the skin, mucous membrane or superficial capillaries is desired. Experiments purporting to show several inches of penetration of living tissues by ultraviolet light have failed to exclude visible light rays from the equation or have failed to take into account the possibility of secondary radiations of any intensity sufficient to affect sensitive plates or films being given off by the rapidly circulating blood *after* it has been irradiated from an intense ultraviolet source. Very crude experiments of my own have convinced me that one or both of these factors are active in any such test. We know that certain salts in solution will fluoresce in the dark for some time after having been irradiated with ultraviolet light and at least one

constituent of the hemoglobin—hematoporphyrin—is fluorescent, and we know that where energy in the form of light waves is taken up, absorbed or transformed in the tissues that secondary radiation, chemical reactions or transformation to other wave lengths takes place. The minutiae of this process have not been worked out exactly in either the case of the x-ray or of the ultraviolet ray, but the clinical reactions *en masse* and the dosage necessary to produce these reactions are known and used constantly. With the large amount of research, both clinical and laboratory, that is being done and the steady progress that is being made, it is only a question of time until every factor in the equation will be known.

The part played by pigment, the lack of its formation in certain cases, the part played by internal secretions, enzymes, hormones, vitamines, anti-bodies, osmosis, photo-sensitizers, the absorption of inflammatory products from the rayed area and autogenous reactions, the power of the group of wave lengths variously known as the actinic ray, the ultraviolet ray, the cold ray or the chemical ray to initiate or accelerate certain chemical reactions both *in vitro* and *in vivo,* the selective absorption of certain wave lengths by certain elements, these and other factors all need much explaining to make them plain to us before we shall consider ourselves competent to attempt to pass an explanation on to others. Because it is impossible at present to explain fully all the details, I shall confine myself to the practical aspects of the question and refer to such things as have been accomplished in the clinic. After all is said and done the final standard of value by which any therapeutic procedure is measured must be its utility in clearing up pathology or relieving pain if the pathology has reached an incurable stage. Judged by this standard I know of very few therapeutic agencies that can be used with benefit over as wide a range of conditions as the actinic ray. I do not intend in this volume to give long series of case histories, but will give my conclusions based upon very large numbers of cases and many original researches, using an occasional case for the sake of bringing out or emphasizing some special point in technic.

There is a tendency in the profession to refer to actinotherapy

or ultraviolet ray therapy as "Sunlight therapy" and to compare results obtained by actual sunlight treatments with those obtained by actinotherapy proper. The sunlight is composed of *all the visible* and *many of the invisible* rays ranging up to the ultraviolet of the longer wave lengths and down into the invisible heat rays in and beyond the ultrared region. The percentage of the ultraviolet rays in the sunlight is small and is very variable, moisture, smoke, dust, altitude, geographical location

Fig. 35.—Another corner of ultraviolet treatment section showing air and water-cooled ultraviolet outfits in use.

and other factors interfering so that it is by no means a constant. The shortest wave length ultraviolet ray ever found in sunlight is one of 2910 Angström units. Such quantities of ultraviolet as are present in the sunlight are of the longer wave lengths and, in common with the violet, indigo and blue of sunlight are depressant in their action on the leucocytes. When we go up into the shorter wave lengths of the far or extreme ultraviolet (not found in sunlight and only the longer far rays in the arc

light) we find that these higher frequency, shorter wave length rays are very stimulating. They are also much more irritating to skin and mucous membrane, more soluble in protoplasm and are much more bactericidal than the near ultraviolet rays. The actinic ray component of sunlight is variable in quantity, is only of the longer depressant wave lengths and is inextricably mixed up with other depressant and stimulant rays so that use of sunlight in therapy is very much indeed like the use of the old-fashioned "shot-gun" prescription. Modern methods have isolated and standardized the active principles of drugs and it is now possible to prescribe a single one of these in exact dosage for an exact effect without having to use a lot of undesirable and more or less unknown alkaloids which formerly were administered with it in the crude drug form.

The actinic ray can now be obtained of infinitely better quality, vastly greater quantity and much more nearly chemically pure than was formerly possible when the sun was the only known source. The difference in clinical effects between the ultraviolet of the sun (and older types of ultraviolet lamps) and that delivered by the modern type of quartz mercury ultraviolet generator is so great that it would almost seem to be advisable to give the shorter wave lengths of the ultraviolet field a distinctive name. It surely is not fair and I do not believe it is very scientific to compare the results of solar-therapy (good as they are in many cases) with those of modern actinotherapy because, certainly, no such short wave length ultraviolet as is given off in quantities from the modern ultraviolet apparatus were *ever* administered to a patient being treated by the sun's rays. If there is any truth in the old axiom that "things equal to the same thing are equal to each other" then the converse is also true and things not equal to the same thing are not equal to each other, and it were time that the effort being made to discredit actinotherapy by some physicians without any clinical experience whatever in the use of modern actinotherapy by quoting statistics compiled from the use of the sun's rays or the old type of ultraviolet lamps should cease.

The arc lamps and the old type mercury anode type of quartz

mercury ultraviolet generators give large volumes of ultraviolet rays of the longer wave lengths and, in the case of the old type mercury anode quartz lamp, some of the medium or far shorter ones. These lamps will tan the skin quicker, affect tint paper much faster, etc., than the tungsten anode type or the modern mercury anode, giving a preponderance of the far or more extreme ultraviolet. Unfortunately the ability of an ultraviolet lamp to tint sensitized paper is no proper criterion by which to judge its clinical efficiency. If it were, the old arc lamps with their unsurpassed *volume* of ultraviolet would be a much better therapeutic lamp than the modern quartz mercury lamp, because they will color up tint paper much faster than any of the latter types. No scientific test as to the relative "strength" of the various types of lamp is of any clinical value if such test depends upon the ability of the lamp to color up tint paper. Neither is any such test of any clinical value if filters are used, as the shorter and most clinically active ultraviolet rays are the first ones stopped by *any kind* of filter yet devised. Neither is the test of any value, clinically, if any of the normal conditions under which the lamp is built to operate are changed. It might not seem fair to a scientist to test two different makes of lamps out against each other if one of the lamps consumed more wattage than the other. It is usual in such cases to raise the wattage of one lamp or, if the type of burner will not permit of raising the wattage beyond its normal consumption, to lower the wattage of the other lamp to that consumed by the lower wattage lamp. If the lamps had been built to operate *on the same wattage* and one of them, through some incidental adjustment, was using more than the normal consumption of current then the balancing of the wattage would be a fair procedure. Another factor enters here and that is that a drop of 4 or 5 per cent below the voltage intended to be used across the burner of an ultraviolet lamp will result not in a loss of 4 or 5 per cent in its clinical efficiency, but in a drop of several times that percentage, because the change alters both the quantity *and the quality* of ray being generated in that burner. No matter how informative and interesting the findings of the precisionist in

the laboratory, unless these findings are based upon or correlated with actual use of the lamp under normal running conditions *with proper technic* upon actual pathologies as encountered in the clinic, checked both by the clinician and laboratory, they are apt to be of questionable value or even actually misleading when attempt is made to interpret them in terms of clinical efficiency.

I was very much amazed some time since upon reading the

Fig. 36.—Corner of ultraviolet section. First four outfits are 1500 watt bulb radiant light and heat applicators. Next four are ultraviolet. (One is in cubicle behind curtains where cases demanding more than ordinary exposure of person were treated.) Commanding officer with hand under first ultraviolet outfit receiving treatment for a troublesome surgical dermatitis. Ionizing x-ray outfit in far end of room, just beyond record table.

first copy of an actinic research bulletin to see it stated that "It is further established that the biologic effect bears the same relation to the intensity of the ray as does the photo chemical effect; so that the one may be used as an index to the other." A famous humorist once remarked when he read a news item announcing his own death, "Important, if true." If it has been

established, who established it, when, where, why, and how? *If* it were possible to have an ultraviolet generator that would generate quantities of the actinic ray all of exactly the same wave length—something at present as impossible as to generate from an x-ray tube quantities of the x-ray all having exactly the same wave length and penetration—or *if* all wave lengths of ultraviolet affected tint paper equally (which they do not) and *if* the exact percentage ratio of the rays that affect the tint paper most to those which have less effect were known and a fixed constant, and *if* a tint paper test made when the voltage on the line had dropped a few per cent showed *less* rapid tinting of the paper instead of *more* rapid tinting as it does, thus causing the exposure time to be shortened when the lamp is working under par and to be lengthened when the lamp is working above par, and *if* the inverse square intensity law held as rigid for ultraviolet as for other forms of radiant energy (which it does not), and *if* the exact percentage efficiency of the biologic effect of the longer rays to the shorter ones were known, and especially *if* these longer rays had the same biologic effect as an equal quantity of the shorter rays (which they certainly do not); as I have said if all these and other uncertainties, such as the personal equation in reading tints, the age and sensitiveness of the tint paper, temperature and chemical composition of the developing water, etc., could be eliminated, then the tint paper test might be acceptable to the clinician if it were not for the further facts that it unduly complicates an otherwise simple procedure and results in impressing both patient and physician with the tremendous possibilities for danger connected with the use of the ultraviolet ray, than which nothing could be farther removed from the truth. If these few faults could be eliminated, the "Actino-quantimeter unit" might hope to face the one question all such methods must face before becoming adopted and that is, *"Is it practical?"*

It is my hearty wish that a simple, accurate and universal method of gauging the dosage of ultraviolet might be devised and put into successful use, but up to date it has not been done. I fear, until the laboratory has solved the many problems put

up to it by the clinician in the way of explaining the *exact* reactions that do take place and the reasons therefor or until ultraviolet apparatus has been strictly standardized as to quality that we shall have to keep on developing and trusting that indefinable but undoubtedly present something which, coming only from experience, enables us to estimate from a review of the factors the proper dosage for any given treatment far more accurately than would be possible by the tint paper test, slide rule, or other similar device. In addition we have the satisfaction of knowing that even if we err as much as 50 per cent in our calculation we are safe. If we underestimate, we can make up the deficiency the next day; and if we overestimate, the worst that can happen will be the formation of a blister. In many of the chronic, indurated skin lesions it is necessary to carry the reaction to the blistering point in some of the worst spots before they will clear up. Thus, far from being a calamity such as a large overdose of the x-ray *used to be,* an overdose of ultraviolet often results in great good. Patients will almost invariably consent to this apparently strenuous treatment once its necessity and safety have been explained to them and after they see the very great improvement following the first reaction, they will often *request* that the dosage be increased at subsequent treatments.

It is impracticable to lay down a rigid minute and inch technic for the use of ultraviolet therapists due to the wide variation both in the quantity and quality of rays generated in the various makes and in the various types of the same make generators, to variations in voltages in various places and to varying ages of burners. The tungsten anode type will give a given intensity of skin erythema with about one-third the exposure necessary to produce this reaction with the same type of older mercury anode lamp. Water-cooled lamps for use on 110 volts AC, as a rule will give a less intensity of ray than the same make of lamp operating from the same voltage on the direct current. Of course, a 220 volt lamp is much more powerful than a corresponding type 110 volt lamp. A brand new and clean burner is more efficient than the same burner will be when it has burned

some hundreds of hours and is more efficient *then* than it will be after additional service of hundreds of hours. The efficiency of a burner does not fall very rapidly under continuous use but it does drop a small amount. If the body of the burner (not the extreme ends) becomes discolored, smoky or blackened it is an almost sure evidence that air has leaked into the burner and excessive oxidation has taken place. There is only one remedy for this and that is to send it to the maker for cleaning

Fig. 37.—Terminal stage of trench foot clearing up under the ultraviolet ray.

and repumping. Often the crack can be found upon inspection but sometimes the most careful search fails to reveal it. A good way to test the vacuum of a burner is to remove it carefully, hold it with the large end down, reservoir pointing to the left, and move it an inch or so to the left, checking it more or less suddenly. This should not be done *too* roughly or the heavy mercury may crack the quartz even if nothing was wrong when the test was started. If the vacuum is all right there will be a

sharp click each time the movement is repeated and the impact of the mercury can be felt very plainly. In handling any quartz-mercury burner the burner should never be turned over end for end *suddenly* as the rush of heavy mercury from the top to the bottom of the burner might easily crack it. If this test shows all right but the burner has been refusing to light or if, after it has been lighted, it clicks at intervals or goes out and is very hard to re-light until it has cooled down and then when re-lighted does the same thing again, the chances are that cutting in *more* resistance in the rheostat will steady the lamp and correct this tendency to click or go out suddenly.

These rheostats are made of coils of wire and the connections to them are made (at least on one end) to a movable metal ring or clamp. The screw tightening this connecting clamp around the coil of wire can be loosened up and the clamp moved up or down so as to put *more* resistance wire into the circuit and then tightened up tight. It is well, if the heat has oxidized these wires to any great extent, to scrape or sandpaper them clean at the point where the clamp is to be fixed so as to make a good electrical contact. Inspect all the lead-in wires and see that all binding post screws inside the hood and any other place where a wire is held under a screw or nut are tight, as the constant tilting of the lamp to light it or the moving and adjustments incident to the giving of treatments may loosen them and cause the lamp to refuse to work. Do not be too ready to blame the burner if the lamp refuses to light. Very often the trouble is elsewhere. The constant swinging of the wires often causes them to break and the most frequent place for this to happen is where the sharpest bend is oftenest made—where the movable wires go into the fixed plugs at either end of the connecting cords. These wires often break, after considerable use, *inside* the plugs either where they go around the screw which attaches them to the plug or a quarter or half an inch down in the insulation. This is caused by the repeated strain put upon them by pulling and pushing upon *the cord* instead of upon the rubber or porcelain plug when plugging in or disconnecting the lamp. This information really belongs in the chapter headed "Trouble

Shooting'' but I believe the best way to remedy trouble is to attack it before it becomes a trouble or, in other words, prevent it so I am inserting it here.

Take hold of the rubber or porcelain plug and pull or push upon that and not upon the wires entering it. This will prevent trouble which is sometimes very hard to locate. Many times, as a favor to some professional friend, I have gone to inspect his lamp and found one or two of the wires leading from the socket to the rheostat or from there to the lamp itself broken in just such a manner. After fixing and testing the lamp I always ask him to connect and disconnect the lamp for me. He usually seizes the cord just back of the plug and, pushing upon both cord and plug, inserts the plug. In disconnecting it he would simply reach over and take hold of the cord at any point and give it a jerk. He is always very much surprised when shown the reason for his trouble.

Inadequate instruction as to how to light and operate the lamps has caused not a little trouble and expense to doctors and hospitals and even in some cases has resulted in the discarding of the outfits as being too much trouble or as being too erratic. One physician was buying fuses by the peck and had had a service man inspect his outfit twice without having located any trouble. I visited his city and he immediately requested me to see if I could lay his ghost. Instead of testing his lines from fuse box to lamp and tearing up the lamp in an attempt to locate trouble (which I suspected was not there) as had the service man, I asked him a few questions and then requested him to light his lamp. He made all the connections right enough but when he tilted the burner he held it tilted expecting the lamp to light. Pop went his fuse. When I explained to him that when he tilted his burner it was only for the purpose of springing an arc and that as long as the solid column of mercury (which flows from the reservoir across to the other terminal when the burner is tipped) was *unbroken* no arc would form and that this unbroken column of mercury was a dead short circuit across his light wires and must be broken at once by bringing the burner back to its original position both for the purpose of breaking

the mercury column and starting the arc and to prevent the fuses melting, he was very much surprised. The only reason he had ever succeeded in lighting the lamp was that he had made some accidental movement which broke the mercury before the fuses had time to melt. After having him light the lamp some twenty times without blowing a fuse I prepared to leave.

As I was going through his waiting room a patient with psoriasis came in for treatment. He asked me to examine the patient and make suggestions as the case was not improving under treatment. I suggested that he go ahead and give the treatment in the regular way and I would discuss the case afterwards. My purpose in doing this was to observe what technic he used in giving the treatment. He turned the water on only very slightly, set and started his interval timer and *then* lighted the lamp, set it at the usual distance and came over to talk to me. While this patient was being treated another patient came in. When the first treatment was finished, he placed the second patient under the lamp at the *same distance and time* and crossed over to talk some more. When this patient had been treated he turned out the burner, cut off the water, and resumed the conversation. In a few minutes another patient came in and he repeated the procedure except that in this case he turned on the water circulating around the burner to such a degree that it splattered from the catch basin on to the floor. From this short observation of his work with ultraviolet (he was a top notch dermatologist) I knew he could not be getting good results, and I had an idea that he would think that the ultraviolet itself was inefficient, so I asked him whose technic he was following. He produced a volume on Actinotherapy by a well-known author and stated that he was following this man's technic "to the letter" and it transpired that he had under preparation at that time a paper giving case reports and condemning, as inefficient, the use of the actinic ray in eczema and psoriasis and, of course, reflecting upon all advocates of ultraviolet ray by inference. He *thought* he was closely following the technic laid down by the author but as a matter of fact he was not even in long range gunshot of it. In the first place the technic he was attempting

to follow had been laid down for a lamp at least two and one-half times as efficient as his own lamp (and this had been plainly stated in the first part of the book), and in the second place he was not doing things the way the author advised and would have secured very erratic results even had he had the very lamp for which the technic was planned.

Here are a few of the errors he was all unconsciously making. When a cold ultraviolet burner is lighted it takes from five to six minutes or more for the mercury to vaporize and heat up to the proper point of luminescence. During this time the amperage is constantly falling and the voltage constantly rising.

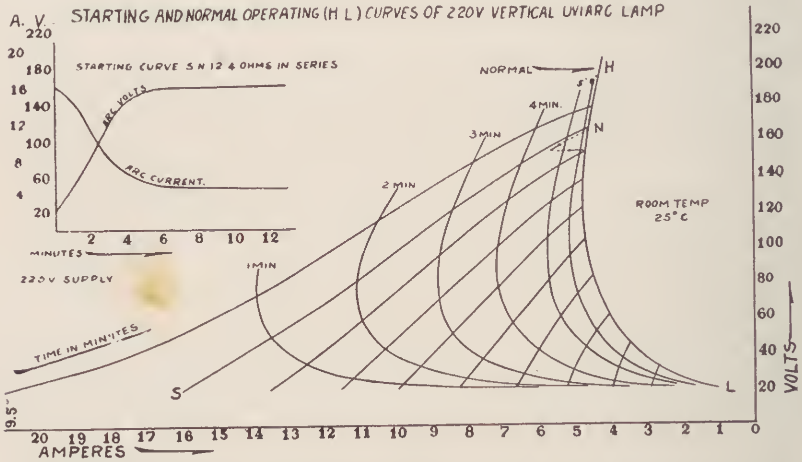

Fig. 38.—Starting and operating voltage and amperage curves of a 220 volt ultraviolet generator. The curves for a 110 volt generator are of almost exactly the same shape and time value but the voltage and amperage at any given minute would be only one half (½) those given for the 220 volt lamp. Note the constant rise in voltage for more than five minutes and the constant fall in amperage. The upper diagram illustrates the voltage rise and the amperage fall very plainly.

As has already been shown, a very slight drop below the normal voltage that should pass through an ultraviolet generator makes a tremendous difference in the efficiency curve of that generator, and until the mercury and rheostat are heated to the normal running temperature, there is a constant variation in the quantity and quality of ultraviolet radiation emitted from the burner. It is worse than useless to attempt to measure dosage under these conditions and a treatment should never be started until the lamp

has reached full efficiency. The first case treated for one minute probably got a much less effective dose than he would have received if the exposure had been one or two seconds with the lamp at peak efficiency. The next man treated received probably two or three times as much *effective* radiation in the minute he received as the lamp was building up all the time and the character of the radiation improving. Had there been a third and fourth case to be treated on the one lighting each succeeding man would have received—in the same time exposure and distance—a *very much larger* dose than the preceding man. After five minutes or so the lamp would have stabilized at maximum efficiency and from then on it would have been possible to gauge dosage.

He made three other mistakes each one of which would have upset his dosage calculations. He set the timer *before* the lamp was lighted in the first case and before the lamp was applied in the succeeding cases instead of setting it first and then *tripping* it at the actual second the radiation began. The correct way is to set the timer hands to the exposure wanted, open or apply the lamp (air or water cooled) and then pull the starting lever back which releases the timing mechanism and starts the counting of time. If the operator is to be in some other part of the room or office the alarm bell can be set to ring five or ten seconds before the time for the treatment is up, and the treatment terminated that length of time after the bell rings. Then, assuming that he had been following the technic correctly otherwise, he forgot to multiply his exposures by two and a half in order to compensate for the difference in efficiency of the two types of lamps. In the first instance, he had a very slow circulation of water around the burner and in the second lighting of the lamp he had a very rapid circulation of water around the burner. In the first instance, his burner heated very rapidly and soon became overheated. In addition to changing the effective radiation emitted had this overheating been allowed to go on for some time it might have ruined his burner and, in any event, it will shorten the life of a burner to run it for long periods *overheated*. In the second case the burner was cooled efficiently, probably too efficiently, but the main objection was that he

never knew *even approximately what he was giving* in the way of dosage and so would seldom secure results, and when he did he could not duplicate them. The metal jacket around the water cooled burner should not be allowed to become so hot that it cannot be held with comfort in the hand. No wonder he was almost disgusted with actinotherapy.

This case is reported in detail not because it occurred, but because it *is occurring frequently* and is resulting in a lot of unfavorable comment and expert opinion being passed around which goes far toward nullifying and discrediting results obtained by some one with a correct technic. I could have purchased this doctor's generator for a fraction of the price he paid for it when I first saw him, but when I saw him five months later he was ordering additional ultraviolet equipment.

Every effort should be made to run generators as nearly under the same conditions at all times as possible. If the operator places an air cooled generator in a strong draft one treatment or plays a powerful electric fan upon it and then the next treatment moves into a dead quiet pocket of air in a corner of the room, he is seriously changing one of its adjustments even though he does not touch any of the adjusting devices on the controls. One time he is using a cool lamp and the next a hot one. It takes slightly more water to cool a burner in summer than in winter due to seasonal temperature of the circulating water.

Some of the ultraviolet lamps have a voltmeter on them to indicate the voltage passing through the outfit. This is very desirable. Even should an ammeter be added so as to give the second factor from which wattage could be calculated (voltage × amperage = wattage) and the most efficient wattage figure for the particular burner furnished from a standardization test at the factory (something not done at present) the reading of the wattage consumption at any particular time would involve a new calculation each time and, not being absolutely necessary, in a busy clinic there is no time for such proceedings, therefore it would not be practical. In cities where the voltage fluctuates according to the time of day and load upon the mains, this variation could be compensated for by a turn of the control on the

variable resistance if such control could be made a part of the unit and the voltage kept constant. Then we could know what our burner was doing at all times and could give exact technics and could duplicate results as consistently as the most expert radiographer. We know that strenuous efforts are now being made to improve the efficiency of ultraviolet outfits and better lamps are sure to result from such efforts.

The burner should be kept clean at all times. The burner of the air cooled lamp reaches such a high temperature that if finger-prints are left on it when adjusting it and the lamp lighted the prints will become etched into the quartz and will markedly lower the efficiency of the lamp by refracting the actinic rays to all points inside the hood and into the air at one side of the patient instead of allowing them to pass directly toward the surface being treated. The ultraviolet differs from the x-ray in this as in nearly all other respects in that it has small penetration and is easily refracted. Alcohol, grain or wood, or Pyrene fluid (the liquid used to fill Pyrene extinguishers) on a clean piece of gauze rubbed over the burner each morning or after each time the burner has been touched will insure its remaining clear on the outside. Do not *assume* that because you have personally warned everyone in your office or institution never to touch the burner that they will not do so. Sooner or later some of them will examine inside the hood some time in your absence and I have known of curiosity seekers tampering around a lamp until they succeeded in lighting it and then, frightened at what they had done, running away and leaving it to burn all night. The most elaborate precautions in the way of special locks, promising to discharge, instantly, any one caught tampering, etc., will not always prevent such tampering. In using a direct current generator one must be sure the polarity indicator reads right or the burners will be ruined.

It being absolutely impractical to lay down a minute-inch technic for the users of the ultraviolet ray because of the many variable factors mentioned above, the thing to do is to lay out a technic that *any man* can adapt to his needs no matter what the make, type or age of his burner may be. Assuming that the

burner is clean, the outfit is lighted and allowed to burn five or six minutes until it has built up to maximum efficiency. This technic is for the 110 volt lamp and the only change necessary with a 220 volt lamp is to cut the exposures approximately in half. Clean an area of skin with alcohol or ether to remove grease, dirt, etc., and divide it into squares of an inch each. Number these squares by dotting them with a dermograph pencil or ink. With an air cooled lamp expose square No. 1 for one minute at 24 inches target-skin distance. The burner or target is in the center of the hood and the distance from the burner to the outside edge of the hood can be measured once for all, and succeeding measurements made from skin to hood and the burner-hood distance added. Say the burner is six inches back of the edge of the hood: then to get a 24 inch target-skin distance the hood would be set 18 inches *directly over* the part to be treated or directly in front of the area so that the central ray from the burner will strike the area under treatment in such a manner that this central ray and the plane of the treated area will form a right angle. Cover all other areas except the square inch under treatment. Any closely woven black cloth, black photo paper, adhesive or similar substance will give full protection. Expose area No. 1 for one minute at 24 inches. Cover area No. 1 and expose area No. 2 for one minute at 22 inches and cover and expose area No. 3 and treat one minute at 20 inches. If the subject is not afraid of being blistered over such small areas it is possible to proceed to treat several more areas, increasing the dosage by moving the lamp an inch nearer the skin at each succeeding exposure. There is not much likelihood of producing a blister until the distance comes down to twelve inches or less but the varying degree of erythema produced by the lesser dosage is valuable to the novice in showing him about what his generator will do.

I divide actinic ray skin reactions into four degrees, a first degree erythema being such a slight reaction that only a very delicate pink can be detected on the treated area when viewed in a good light and which is not followed by easily *visible* exfoliation of the epidermis. A second degree erythema is one

where the reddening of the skin is apparent at a glance after the reaction has appeared, the patient experiencing subjective symptoms of a mild sunburn and is followed by a granular exfoliation of the epidermis. A third degree erythema results when the exposure has been a little more intense and the part presents all the appearances of a heavy sunburn, the epidermis coming off in *strips* or *squares* sometimes several inches across. The symptoms are those of a severe sunburn and occasionally, in certain individuals, a cellulitis of the subcutaneous structures ensues. This occurs infrequently, however. The fourth degree erythema is blister formation. The reaction begins to be visible at varying times after the exposure. The usual time is some three to six hours but we have seen cases where the erythema was visible in a few minutes after the exposure.

By treating three or four areas on one day and waiting twenty-four or thirty-six hours for the reaction to reach its maximum the discomfort of excessive blistering which might result if multiple areas were treated at one sitting is cut to a minimum. However, if time presses, treatment can be started at one minute at 15 inches, one at 14 inches, one at 12 and one at 10 inches on successive areas at the first sitting. If when the dosage has been increased to one minute at 10 inches no blister results the distance can be held at that point—10 inches target-skin—and at the time increased fifteen seconds on each area until the exact blister point has been located. Some alternating current lamps will produce a blister before the ten-inch distance has been reached. When the blister point has been located, take a piece of adhesive plaster, mark on it in ink the dosage required and stick it on some part of the outfit where it can be read at a glance. In converting technic from one target-skin distance to another the inverse square law of light holds near enough true with the ultra-violet that it can be used. This law is that the *intensity* of light varies *inversely* as the square of the distance. Thus if it were found that a certain lamp would blister in one minute at ten inches and you wished to know how to give the same dosage from a distance of fifteen inches you would square 10 which equals 100 and square 15 which equals 225. If the intensity

varied *as* the square of the distance then the same time exposure at 15 inches would give two and one-fourth times the intensity, but as it varies *inversely* as the square of the distance it is apparent that the greater the distance the less the intensity so that in this case to secure the same dosage or intensity from 15 inches as from 10 inches would require two and one-quarter times as long an exposure and you would have to give two and a quarter minutes at the greater distance. As a matter of fact halving the distance a little more than quadruples the dose. The intensity varies *as* the length of the exposure, therefore the longer the exposure at any given distance, the greater the intensity and the consequent reaction. It will usually be found that cutting a fourth degree erythema dose one-fourth will result in the production of a third degree erythema or that increasing a full third degree erythema dose one-third will convert it into a fourth degree erythema.

If a water cooled 110 volt lamp is to be standardized, the same general procedure can be followed except that the front window of the lamp is placed in contact with the skin (not under pressure) and the exposure on area No. 1 started at five seconds, the next area being given 10 seconds, the next 15 seconds, the next 20 seconds, etc. The blister point in contact for the better types of water cooled lamps averages much less than one minute in contact and a particularly good one might blister in a fraction of a minute. If the quartz compression applicators (about one inch thick) are used, the blister time is raised somewhat as there is a small space between the front window and the quartz. In treating mucous membranes a full minute's exposure through any of the hollow metal applicators—the burner being about 4 inches from the surface of the membrane—with an average lamp will produce a mild reaction, two minutes will produce a marked reaction and three minutes will blister or cause marked exfoliation. Mucous surfaces as a rule will stand more exposure than skin surfaces. A minute and a half at about a 4 inch distance is my usual exposure for treating a pharyngitis or a clergyman's sore throat. If the exposure is given *through solid fused quartz* rods less than one minute in contact under compression

(as in pyorrhea) will blister. I have long contended that an ultraviolet treatment at a given distance administered through a solid fused quartz applicator was more efficient than the same treatment from the same lamp was if administered through the air at the same target-skin distance but up until December, 1921, had no irrefutable proof. Clinical experience demonstrated this fact to me early in the work, but my assertion that this was the case was received with disbelief.

In December, 1921, a joint clinical meeting of the American Electrotherapeutic Association and the New York Electrotherapeutic Association was held in the Physiotherapy clinic at Fox Hills Hospital. Among others attending were Dr. Schubmehl, works physician of the General Electric and Mr. Berry of the Research Laboratory of the General Electric at West Lynn, Mass. Mr. Berry brought with him a number of pieces of fused quartz to demonstrate the transmission of the ultraviolet by that material. One of these pieces of fused quartz was of about the diameter of a small lead pencil, shaped like an elongated corkscrew, having some two and a half complete turns in it and thirty some odd inches long. Another piece was shaped like an elongated letter S so that light transmitted around it emerged in the op-

Fig. 39.—Set of three quartz rods for applying the ultraviolet to the gums —a straight, a 45° and a 90° angle. These quartz rods *must* be crystal clear and free from roughness or waves and should have practically no air bubbles in them. Any unevenness in them or air bubbles serve to refract the shorter ultraviolet rays out to the side and these extremely short rays are the very ones desired. They do no good unless they are delivered into the tissues under end of the quartz rod.

posite direction from that in which it entered. When these two pieces were placed end to end the visible light emerging from the end (distance forty-six inches from the water cooled burner) looked to be as intense as that emerging from a straight piece four inches long. After the transmission of visible light through the long quartz rods had been demonstrated to the different sections of the assembled physicians I conducted a private experiment of my own. The distal end of the longer rod was placed and held in firm contact with the skin of a forearm and a two minute exposure given. A blister the size of the end of the quartz rod resulted, while the same time exposure of a contiguous area with the same lamp at the same distance *but through air* hardly produced a first degree erythema. This would seem to set at nought the inverse square law and to a certain extent we believe that it does, as the inverse square law certainly applies to air transmission, modified. Thus, halving the distance a little more than quadruples the dose while doubling the distance a little more than quarters it, but, at least in the case of ultraviolet, we know that clear-fused quartz has a very much higher transmission coefficient, or in other words, very much less absorption than an equal volume of air. This and subsequent experiments have conclusively proved (at least to my own satisfaction) that a solid clear quartz rod makes a more efficient applicator for ultraviolet than a hollow metal (air filled) tipped with quartz.

The part played by pigment (tanning of skin under ultraviolet applications) has long puzzled us. At first we were inclined to give credence to the opinions of some of the writers on light therapy that the pigment itself had some considerable part in the reactions, possibly by transforming one wave length to another, because it was an obvious fact that those patients, especially malignant or tuberculous, that tanned quickest, made the fastest improvement. About three years ago when the advance models of the newer type tungsten anode lamps were made available for clinical trial I was much interested to note that even more rapid clinical improvement followed in these cases under the new lamp, but that the tanning was very much less than formerly. This

gave the pigment function theory quite a jar and caused me to run a series of forty-four pulmonary tuberculosis cases of all stages in an attempt to secure further information on the subject. From exceedingly close observation of this class I found that while the improvement in nearly all of them was more rapid than had formerly been the case, tanning, while it occurred with about the same frequency as formerly, was also very much slower. Another significant fact was observed and that was that untoward systemic reactions were observed in some of the cases where tanning was not taking place or where it was so slight as to be hardly noticeable, and this from exactly the same actinic dosage that produced no excessive reaction in any of the tanned cases except one. (He went off on a three day "third-rail" whisky spree and was dropped from the series when he repeated.) In other untanned cases no reaction (systemic) occurred even when exposures were increased. Those cases in which tanning did not take place had to be treated with a special technic, using reduced dosage and less frequent treatments or increased dosage, and finally in 60 per cent of *these* cases we had to add other treatment before they slowly began to improve. Two of the seven cases had not improved when the entire series was abruptly terminated because of interference from a powerful outside source, but I had the data necessary to enable me to form an opinion as to the significance of pigment. As a result of these and other observations I have concluded that as a general thing pigmentation is chiefly valuable as an index of the reactivity of the patient. I may be wrong in this but the fact that for the last two or more years I have been using this phenomenon as a basis for prognosis and that I am able to feel the cases out with small exposures and avoid excessive reactions and save invaluable time in some cases by adding proper adjuncts early instead of after the case has lost much valuable ground has so firmly established this reactivity test in my mind that it is going to take considerable more than theory to cause me to abandon its use.

The question is often asked as to why I differ with others advocating the *preceding* of *every* case of application of the ultra-

violet ray by long applications of radiant light and heat. I disagree with them only in part. Radiant light and heat, especially from some of the modern "Deep Therapy" lamps of high wattage and proper construction is an invaluable adjunct in any therapy clinic and we use numbers of them constantly but always for local effect. The application of light from such an outfit is a combination of convective and conversive heat to the part except that the conversive heat area is limited to the superficial tissues or tissues such as cancellous bone which admit of penetration of sufficient volume of the rays to actually raise the temperature of the part several degrees. That the rise of temperature to such an effective amount is limited to the surface treated or at most to a limited depth is known and admitted by most of the advocates of this procedure. Thus diathermia, the most effective form of heat, is preferable for heating any except superficial tissues. The fact that a local reaction (skin or wound surface) from ultraviolet light is much more efficient if the underlying tissues have been heated, (witness the marked effect of the combination of indirect diathermia and ultraviolet ray in hay fever, vastly more effective than the use of either singly) the fact that the greatest heat in diathermia is not on the surface while that from radiant light and heat is, and the further fact that such application of radiant light and heat can cover large surfaces and is easily applied makes the use of the deep therapy lamp almost indispensable when treating *local* skin lesions and open wounds.

The use of radiant light over any considerable area has one effect seemingly ignored by the advocates of its use in treating chronic disease in other structures than the skin, and that is that such application of radiant light or of sunlight *through glass* (which removes much of the shorter ultraviolet wave length) is always followed by a drop in the leucocytes, and that such drop persists, roughly, for a couple of weeks. Clark (Clark, Janet Howell, The Action of Light on the Leucocyte Count, American Journal Hygiene, Vol. 1, No. 1, January, 1921), illustrates this fact very strikingly in a series of animal experiments. Not only are the green, blue, indigo and violet of the visible spec-

trums depressant, but the longer ultraviolet wave lengths as well. The yellow and red are stimulants, but in radiant light from incandescent sources the depressant action predominates. Further screening out of the ultrared, red and orange rays makes the application of the light more sedative in character but also makes it more depressant. The far ultraviolet and the extreme ultraviolet, on the other hand, are stimulant and irritant and I have seen the leucocyte count go well over one hundred per cent in less than five days after a single application of ultraviolet from the modern quartz mercury burner—rich in these rays—and stay above normal for three weeks. In view of the facts that it is generally considered that a leucocytosis is desirable as a part of any reparative reaction in chronic disease; that it has been proved by Amos, Taylor and Witherbee (Amos, H. L., Taylor, H. D., and Witherbee, W. D.: Effects of Large Doses of X-rays on the Susceptibility of the Monkey to Experimental Poliomyelitis. Jour. Exper. Med., 1919, xxix, 115) that monkeys with greatly reduced lymphocyte counts from heavy x-ray exposure show a markedly increased susceptibility to an intracerebral inoculation of poliomyelitic virus filtrate; that numerous experiments at the Rockefeller Institute by Murphy, Sturm and Taylor (published in various numbers of the 1919 Vol. of Jour. Exper. Med.) tend to show that a marked rise in the lymphocyte count increases animal immunity to transplanted cancer grafts or tuberculosis; that while our clinical results with the joint use of radiant light and ultraviolet in chronic diseases other than those of the skin were good, since ceasing the preceding of the ultraviolet with general applications of radiant light and heat in the last two years the results have been more prompt and positive, it is not difficult to see why I practice and advocate the omission of the light application in these cases. This also answers the statement that it is necessary to dilate the capillaries and bring the blood to the point where it can be reached by applying radiant light and heat as we did not increase our actinic exposures a single second in duration. On the other hand we soon *found it advisable to* begin *decreasing* the length of exposure. So my general rule is that for local reactions I use the combination of radiant

Fig. 40.—Treating a tuberculosis ulcer of the lip with a water-cooled ultraviolet generator and compression.

light and heat and the ultraviolet light, and for tonic or constitutional treatments I use the ultraviolet light alone. In many cases I use the combination locally and the ultraviolet alone generally. It is surprising how much better *local* repair progresses when *general* radiations of ultraviolet are added.

The dosage used in any given case will vary according to the nature of the case and in local lesions to the stage of chronicity as well. In treating skin lesions the general rule is that the more chronically inflamed the area, the shorter the wave length and the greater the reaction to be produced. A third degree erythema produced at 24 inches is not exactly the same thing as a third degree erythema produced at six inches. At six inches many rays reach the skin (shorter wave lengths) that would never penetrate twenty-four inches of air. The air, in ultraviolet light therapy may, in a way, be made to take the place of filtration in x-ray therapy except that the wave length rule is reversed. In x-ray and radium therapy it is the shortest wave length that travels through the most filtration but in ultraviolet therapy it is the longest wave length. Quartz, itself, which is much less absorbent to ultraviolet than air, absorbs the ultraviolet rays having a shorter wave length than 1849 Angström units while the longer wave lengths of ultraviolet will penetrate through the many miles of air surrounding the earth and have been used for secret signalling (they are invisible when accompanying visible rays are excluded) over long distances. The shorter wave lengths, in addition to being more soluble, are more bactericidal and more irritating than an equal quantity of longer wave lengths.

Thus, when we are called upon to treat a case of acute sunburn we would be foolish to use a very short target skin distance even with the time of exposure cut to compensate the inverse square intensity law. What is desired here is the sedative effects of the longer rays which very greatly predominate at long target skin distance so that a forty inch target-skin distance would be used, and less than a first degree erythema exposure. If we used the more irritating short rays and gave a second degree exposure we would add insult to injury. With

this mild exposure of the sedative rays a very soothing effect is obtained and the exposure can be repeated in a few hours.

When we are called upon to treat one of the tineas for example then we want to produce a complete dermatitis of the whole thickness of the skin and we would use a short target-skin distance (eight to twelve inches) and give a good third degree erythema exposure. One such exposure is enough for one area provided the skin has not been chronically inflamed before treatment so long that it has become indurated. When induration is present the difficulty in producing a reaction of sufficient intensity to include the deeper layers and sterilize the skin is much greater. It may be necessary to soften the skin up with an ionizing dose of x-ray repeated not more than two or three times at intervals of two, three or four days and then apply the actinic ray, preceding the ultraviolet with twenty or thirty minutes of radiant heat. If a ringworm of the scalp is being treated, it will be necessary to shave the head over the affected area or at least to clip it closely. Unless this is done there will be the greatest difficuty in getting enough of the ultraviolet onto the skin to produce a sufficient reaction. The area *can* be treated by moistening the hair, parting it and holding the parted line open with gloved hands, exposing and repeating many times, making each parted open path lie just alongside the last but these reactions are not so even and are very tedious to do. Just why a patient should persistently refuse to have the head shaved or clipped and ultraviolet applied—all three measures to stimulate more rapid hair growth—and then take the dangerous epilation x-ray dosage with its much longer bald sequel and the danger of atrophic skin changes following, is hard to understand. It is not the effect of the x-ray itself that does the work, it is the dermatitis produced (and if no dermatitis is produeed then no cure results) and one who knows both methods of producing the dermatitis is hardly going to choose the dangerous method when he has an absolutely safe method that produces a more intense dermatitis in a shorter time.

The ionizing dosage of x-ray referred to is the dose with these factors: 5 inch back up spark, 8 inch target-skin distance, one

millimeter aluminum filter and a five milliampere-minute dose. This is one milliampere for five minutes, two and a half for two minutes, five for one minute, etc., and *not 5 ma.* in the tube *for 5 minutes* which would be a *twenty-five* milliampere minute dose.

This ionizing dose of x-ray is a necessary addition to the ultraviolet in those chronic indurative acne cases where the ultraviolet alone will be unable to produce a sufficient reaction while the skin is hard but will do the work after the x-ray has been applied and the induration lessened. This dosage of x-ray alone would do no good and it is not used in dermatitis-producing dosage, but only to help soften up the skin and make it more reactive to the actinic ray. After using the combination for a couple of years we had a very bad case of dermatitis exfoliativa sent in to us for treatment. He was so repulsive looking that he would not receive visitors. His features and skin were much swollen, his skin thickened until in many places it felt to be an inch thick, would scarcely bend, and had nodules all over it, some few of which were pustular. He gave a history of having had the condition for eight years and of having been under observation for three months at one time for suspicion of leprosy. Many diagnoses had been made, but the final one was dermatitis exfoliativa. Many Wassermanns had been done upon him at various times, all negative. All treatment had proved futile. He was a merchant seaman, thirty-eight years old, family history unimportant. We decided to try the actinic ray alone upon one side of his body and the actinic ray plus the ionizing dosage of x-ray once every five days upon the other. Both sides improved from the start and in ten weeks he was going over to the city and all over the hospital. His face and hands cleared up first. The side receiving only ultraviolent improved up to a certain point—some clear areas but others still indurated and stationary. The other side cleared up evenly and steadily. When I added the x-ray to the first side it cleared up rapidly to a point corresponding to the other side and then progressed evenly with it. He was transferred to another hospital before he was completely cured, but the staff gave us credit for a score, as he was almost clear when he left and was improving steadily. Before

being sent to our hospital he underwent every indicated medical treatment, vaccines and three courses of x-ray and was referred to us with the remark, "Here is *one case* that will dull your axe." We made no promises, at that, when we started him upon treatment and were little less surprised than the skin section when he made such good improvement.

Ultraviolet ray, locally and generally is strongly indicated in skin and bone tuberculosis, but in the latter caution must be used. If there is a pulmonary lesion (and in some cases pronounced negative by the T. B. service after long search, the allergic reaction stirred up by too vigorous local treatment revealed one) then the treatment must not be too vigorous at the start. If the local treatment stirs up more than one degree of temperature, increases the pulse, causes a lowering of the effort syndrome, malaise, etc., then treatment should be given as in an advanced pulmonary case—very carefully. In lupus vulgaris often, after the first few actinic ray treatments a *dermatitis dose* of x-ray is of the greatest utility. Of course, this treatment alone will clear up some cases and so will the actinic ray, but together they will do much better work. Wherever the ultraviolet is used to *increase skin tolerance* for attack upon deep pathology through the skin with the x-ray (see Leonard Research Thesis) then the x-ray is *never* given *while the skin is inflamed* from the ultraviolet. The ultraviolet reaction is allowed to die down before giving the x-ray. In lupus the intensified dermatitis is desired so the x-ray is given regardless of the presence of any ultraviolet dermatitis and later cleared up with the ultraviolet. This gives results that I never have been able to get with any other remedy or combination.

The Leonard Research Prize Thesis (the title of which really should have been "A New Method of Increasing Skin Tolerance to Massive X-ray Dosage" has now been submitted for two years and has been published several months and we are receiving reports of men who have tried out the method. One roentgen therapist, Dr. F., reports that by the use of the method and a twenty inch x-ray machine he has more than once succeeded in breaking down healthy tissues under an uninflamed and ap-

parently undamaged skin by direct radiation—no crossfire rays traversing the broken down area. He further bears out our observations by saying that roentgen sickness occurs very rarely in his practice now and never so severe as when *smaller* doses were used *without* the ultraviolet. I have never contended that the ultraviolet protected the *subcutaneous* structures *absolutely* but did state that "whether the blood-chemistry changes which follow the application of ultraviolet light have an antidoting or damping effect upon the cycle of tissue changes set in train by massive x-ray dosage, cannot be stated positively at this time," etc. I made this statement deliberately because we knew that the maximum protective action was upon the skin itself and *anything* that would increase *skin tolerance* would much increase the efficiency of deep x-ray therapy and I made the further statement that "no matter from what angle the problem is viewed, the breaching of the stone wall of skin tolerance will allow entrance to new research fields." This was my main object in submitting the thesis at that time—to start large numbers of roentgen therapists to doing research work and find out just where the limits were. We knew that the closure of our hospital was imminent and doubted whether we would be able to carry the work much farther before disorganization of the hospital checked our incompleted researches. I would like nothing better than to have unlimited resources and time to carry out researches along this line and, with the addition of other physical remedies, into the field of malignancy. I believe that ultimate cure—if cure there is—lies in this direction just as many other very intractable conditions have yielded to properly blended physical remedies. If *increased* x-ray dosage with shorter wave lengths up to the limit of survival of intervening or surrounding healthy tissues does not solve the riddle then I believe that an entirely different line of attack will have to be laid out.

Some of the worst looking cases of general psoriasis that we have ever seen were sent in for treatment. Some of the more recent areas cleared up promptly under actinotherapy, but some of the older and more indurated regions were intractable until

the ionizing x-ray dose was added when they cleared up also. The actinotherapy in these cases must be vigorous to do the most good. Third degree reactions are the rule and on particularly stubborn lesions compression fourth degree dosage will have to be used. It is a waste of time to treat these cases with the ultraviolet ray if the patient or ward nurse *persists* in plastering the skin with some ointment or even plain vaseline in the intervals between treatments. It takes a day or two to remove such greasy substances sufficient to allow proper actinotherapy. It is a waste of time to try to produce a reparative reaction with ultraviolet through *scales,* layers of powder, etc. Again, what is the use of trying to produce an intense reaction

Fig. 41.—Empyema case receiving general ultraviolet ray treatment.

if, at the first burning sensation the patient experiences as the reaction starts, the reaction is going to be stopped or markedly cut down by the application of antidermatitis remedies? An anodyne by mouth possibly does no harm, but a local one to the skin surely does. A layer of talc which, in the absence of grease, can be removed easily, will give some comfort in preventing pain from friction of bedclothes, etc., but sprays of volatile substances, lotions or grease should not be used. These patients, once the necessity for the heavy reaction is explained to them, will cheerfully stand these reactions and often will insist upon larger areas being treated at one time than the physician deems advisable. It is surely striking to observe the extreme

rarity of recurrences where the areas have been thoroughly cleaned up by this process. Again we believe that the saturation of the patient's blood with the ultraviolet during the local treatments does things to the dyscrasia (whatever it is) that reduces the chance of recurrence to a minimum. This is in contrast to many other methods where recurrences on early treated areas are the rule before later areas are cleared up. This brings us to the statement that, really, there is no such thing as a *strictly local* ultraviolet treatment. There is *always* some measure of constitutional reaction the intensity of which varies as the area and dosage.

Eczemas are treated variously. For dry scaly eczemas the treatment is about that for psoriasis. For acute weeping surfaces the more sedative rays would be used. Blood chemistry studies should be made upon these cases and diet regulated by the findings.

Rhus tox is treated with the longer rays. Carbuncles and boils are treated with an erythema dose of a five or six inch back up spark x-ray through one millimeter of aluminum filter and then compression ultraviolet applied with the water cooled lamp to a third degree erythema dose right after the x-ray treatment is finished. If the water cooled lamp is not available then the air-cooled may be used at a seven or eight inch target-skin distance and the same degree erythema dose given. The inflamed follicles in boils and the whole cellulitis area in carbuncles should be covered and an inch or more of healthy skin on all sides included. If applied before tissue breakdown (pus) has occurred one such treatment is nearly always enough to stop the process short. The ultraviolet may be repeated as the erythema from the preceding exposure dies down and it is not a bad idea at all to give a second degree erythema actinic ray exposure to wide areas surrounding the boils or carbuncle to cut short other infected follicles. General ultraviolet exposures are as valuable in these cases as in many others. If a boil or carbuncle case comes in for treatment after masses of pus have formed then the condition is past the preventive stage and would be treated as any other abscess—incision, drainage and *then* the x-ray-ultra-

violet ray sequence which will markedly hasten resolution even at this stage. If a carbuncle comes in early and refuses to respond to this treatment, then we would suspect diabetes and, no matter what the urinalysis failed to show, would do a blood chemistry test with special reference to the blood-sugar content. We have found in every case but one that failed to respond to this treatment a blood-sugar content away above normal and such failure has become a diagnostic point with us. Many of these cases showed no sugar in the urine. The same thing holds when a normal dosage of the ultraviolet is followed by an excessive general reaction. We have had comparatively few diabetics to treat (the medical service is making close study of these cases, weighing their food to the grain, doing metabolism tests, etc., on them and regulating their treatment so closely that they do not want any disturbing factors in the way of physiotherapy introduced—for which one can hardly blame them) and these were mostly cases we "discovered" while treating skin conditions. We understand that others, working in their own practice (and thus able to hold their diabetics when they find them) have had some measure of success in being able to treat these cases with ultraviolet ray, but we must confess that every case that we have tried to treat has reacted so unfavorably to the actinic ray that we were glad to cease the treatment. Possibly, had we preceded all ultraviolet treatments in these cases with prolonged general exposures to radiant light (which we did not) the hypersensitiveness might have been reduced to a point where anaphylactoid reactions would not have occurred. We know that simply reducing the ultraviolet dosage failed in our hands.

I was fortunate enough to be stationed at a service general hospital seven months where Dr. Frederick Allen had charge of the physiological laboratory and the diabetic service and I attended a short series of lectures given by him. During this series he stated that in every case where he had been able to secure an autopsy within a few hours after death and before autolytic changes had masked the pathology, he had been able to demonstrate the presence of a pancreatitis in this class of

cases. He preferred at the time (1918-1919) not to state whether in his opinion the pancreatitis was a cause or a sequel and I have not since seen any positive statement by any one on this point, *but* if the pancreatitis is the cause or a major cause then we have a very positive method of attack as the "itis" in the pancreas should be no harder to damp out than other "itises" of deep seated organs or structures.

The untoward reaction of a diabetic to the actinic ray may be anything from chilly sensations and a mild headache to a condition simulating surgical shock or even anaphylaxis. There is generally a marked malaise for two or three days and Plank states that he has observed amnesia and loss of will power.

One of the more unusual uses for ultraviolet ray is in the treatment of trachoma. Here I use the quartz rod pyorrhea applicator (45° angle) and compression giving third degree erythema exposures. The resultant cleaning off of the membrane, *the lack* of production of *additional scarring* and even the *removal* of *some* degree of scarring make this method one of choice if it proves out. The one case I used it upon showed such prompt and perfect response that I am anxious to see it tried fully.

In the various forms of conjunctivitis the ultraviolet ray will prove exceedingly valuable. One physician consulted me two years ago about a very stubborn case of tuberculous conjunctivitis in a young girl. I advised a third degree erythema dose of ultraviolet and advised treatment of one eye at a time on account of the rather violent reaction produced. He thought (as he later stated) that he might not get a second chance at the case, so treated both eyes at the first treatment. His description of the reaction of the treatment upon the child's father is rather amusing. He stated that this father's first reaction was one of homicidal mania and that the secondary reaction (a few weeks later) was one of incurable ecstasy.

In this connection it is well to state that a few seconds' direct exposure of the conjunctiva to ultraviolet light unprotected by glasses will produce a *painful* but not dangerous conjunctivitis. If an operator of a lamp is giving repeated treatments every

day the simple expedient of staying out of direct radiation will not prevent a conjunctivitis, especially if white sheeting is used as a covering for the patient. Enough ultraviolet will be reflected to cause a painful inflammatory reaction in the conjunc-

Figs. 42 and 43.—This man's entire body except the articular surfaces was covered with a scaly, pustular eczema which had resisted all treatment for twenty-two months and was rapidly becoming worse. These two photos were taken at an interval of ten weeks and three days. The legs proved harder to clear up than other areas. No other application was made than that of the ultraviolet ray. The spots in the last picture are not spots of the eczema but are permanent scars where the skin was destroyed by the pustules.

tivae so that glasses or goggles should be worn if the operator is around the lamp frequently. It is a good precaution anyway and if the patient is being irradiated around the face or upper chest his eyes should be protected by goggles or a folded cloth laid over his eyes. More than once I have had to take "time

Fig. 43. (See Fig. 42 for description.)

out" for an aide who thought that by staying out of the direct rays she could leave off the unbecoming goggles, and upon one occasion the dosage was strong enough to produce a third degree erythema all over her neck and face in addition. She was handling two or three lamps during the illness of one of her

assistants and simply got too much—either direct or indirect or both.

The use of the term "violet ray" to describe these little corner drug store, monopolar high frequency vacuum electrode outfits is particularly unfortunate, as many physicians, even, think there is some relation between them and *ultra*violet ray generators and we have already come across more than one instance of where a purchaser has been allowed or prompted to think that he was buying something that was practically the same as *ultraviolet* when he secured one of these cheap therapeutic toys. The line of bunk that the "expert" demonstrators for some of these companies vending these things put out is farcical and some of their advertising positively disgusting. The only reason that incalculable positive damage is not done every hour in the day by the lay users of these things is that they are almost one hundred per cent lacking in the power to do what most of the venders claim. This does not take into account the many curable conditions that are allowed to progress to an incurable state while some one is pecking at the surface of the skin with one of these puny "violet ray" outfits, where if he had not delayed the inevitable visit to the physician too long a clearing up of the process would have been easily possible.

In the clearing up of infective areas the ultraviolet is invaluable. Sinuses, when opened up and pus removed should receive *overexposures,* quartz rods of various shapes being used to get into the corners and pockets and general tonic exposures given concurrently. Infected apical areas may be sterilized by compression into the socket after extraction. In case it is not possible to project the rays *directly* onto the area then general raying should be resorted to and this general raying alone is often sufficient to clear up such areas, drainage having been established. In beginning periostitis the action of local and general actinic radiation is often remarkable. Because of its action in raising the oxidation index and its activating effect upon blood it is indicated in all so-called toxemic conditions and conditions tending toward the state known as acidosis. Diabetics with skin or local lesions should be treated very cautiously until it is

determined whether they react excessively to the actinic ray. Anemias are a very strong indication. The action of ultraviolet in rachitis is positive and well known. The literature contains the results of many researches in this connection and they are more than worth intensive study.

For the treatment of acne rosacea, port-wine marks, etc., the compression method is used giving heavy overexposures, waiting for the epidermis to exfoliate and repeating as necessary. The efficiency of this method of removing superficial disfigurations and the total lack of scarring when properly done make it the method of choice.

A word should be said about why old burners are not so strong as newer ones. Due to the intense heat of the arc enclosed by the quartz there is a *very* slow change taking place. Very gradually certain almost microscopically small particles of quartz are converted into tridymite. The exact transparency of tridymite to the shorter actinic rays is an unknown quantity as yet, but we do know that it is not so transparent as pure quartz. It is probably more transparent than glass. The result is that as more and more tridymite is formed in the burner, less and less of the shorter rays can get through. It affects the longer rays little if any. On account of the better cooling of the water cooled lamp this change is slower in a water cooled than in an air cooled burner. It is estimated that one thousand hours of service with the air cooled burner cause the formation of enough tridymite to interfere with the delivery of short rays in quantity and that a service of from 1500 to 2000 hours shuts off all the shorter rays, letting through only the near ultraviolet and a part of the far. Thus, nearly every one starting to use ultraviolet will add more lamps to his equipment later on and when new lamps are received they should be put to work upon the cases requiring the use of short rays and the production of a leucocytosis when desired and the older lamps used for tonic treatments where the more sedative long rays have demonstrated their ability to secure results. When a burner has had long service, it is economy to pay the slight difference in cost between repairs on a *new* burner and secure the latter.

In the produetion of a leueocytosis the best procedure is to use the shorter rays over large areas for the first treatment, wait four or five days and then treat daily at a distanee of from 24 to 40 inehes until the leueocytes have reaehed a level line and

Fig. 44.—A pustular folliculitis which had resisted all treatment (including two series of unfiltered x-ray) for more than a year before being sent to the physiotherapy service. Cleared up in less than two weeks under the shorter ultraviolet ray dosages administered. Two-third degree erythemas were produced at a target-skin distance of seven inches.

then move down close and repeat the cycle. The typical leucocyte curve, plotted from many cases, is a drop in the count for a few hours then a rebound to the starting point and on up for some five days when the curve begins to fall, rapidly at first and then slower until the base line is reached in eighteen or twenty days. There is often a secondary rebound on the tenth or eleventh day but not up to the peak and this secondary increase seldom lasts over a day or so. Just what produces this secondary rebound when it does occur has not yet been worked out. Not all cases treated will show a leucocytosis, but I think that the absence of a leucocytosis after a general exposure such as outlined is a very good evidence of lowered reactivity or the presence of toxins interfering with the reaction. Many cases failing to show this leucocytosis at the start of their treatment did show it after a few weeks of tonic raying. We started a research upon the effect of stimulating the spleen with small doses of x-ray on the second or third day after the start of a leucocytosis so that the reaction would occur at the time of the secondary rebound in the leucocyte curve in a series of pulmonary tuberculosis cases but the treatment of the entire series was terminated before we had had time to draw positive conclusions as to whether the addition of this procedure hastened the already rapid progress of these cases.

A few words here may save considerable annoyance and expense to users of the fragile type of ultraviolet generators. We had as much trouble as any one with these burners breaking. Repeated service requests were met by the maker but the trouble continued. We made a study of these burners and noted one fact. The burners (in our clinic at least) never broke while operating or while starting the lamp. We always found them broken (when a break occurred) when we went to light them up. They had been all right the day before or the half day before. This would indicate that the cracking occurred in the *cooling* of the burner after use. We ran a series of experiments such as burning a lamp forty-eight hours consecutively and the burners stood up. We experimented some more and found that if the water on the water cooled lamp was cut off *before the*

current was cut off and the stagnant water and its containing jacket allowed to heat up so as to be *warm* to the touch (not *hot*) that the whole lamp—burner, water, jacket—was prevented from cooling suddenly and from that time on the only burners that were broken were broken when some one carelessly cut off the current and left the cold water flowing around the burner. The same thing proved true of the air cooled lamp. By closing the hood and laying a towel over the hood and allowing the burner to burn a few seconds at the end of the period of the lamp's service before turning off the current, the air and hood warmed up and prevented sudden cooling of the burner after

Fig. 45.—Close up film enlargement of terminal healing stage of an empyema case. Resection of ribs, decortication operation and subsequent osteomyelitic infection of all bone ends with three subsequent operations to eradicate the osteomyelitis. Cleared up rapidly under diathermia and local and general ultraviolet ray treatments.

the current was shut off. We believe that even those burners that did break (some did break while operating in other services) during use broke as a result of a stress or crack sustained *at the last cooling.* We have given this information to the maker to work out. We *know* that it lessens the breakage even if it will not prevent it entirely as we have not lost a burner since adopting it.

Brief General Summary.—The application of ultraviolet ray is followed by two reactions—a local and a general. The local is manifested by varying degrees of erythema and the general

by various blood chemistry reactions the sum total of which may be said to be decidedly beneficial in many morbid states.

The ultraviolet ray is almost as different from the x-ray both in its local and general effects as is the positive galvanic pole from the negative. The heavy ultraviolet reactions are constructive where heavy x-ray reactions are destructive.

The ultraviolet itself does not produce "burns."

The ultraviolet ray will not penetrate through blood.

The shorter the ultraviolet ray, the less penetration, the more stimulating it is and the more bactericidal.

Actinotherapy is not synonymous with sunlight or heliotherapy.

The tint paper method of measuring ultraviolet dosage is wrong in principle and practice.

Each individual burner should be standardized on the circuit from which it is to be used.

The burners should be kept clean. Lack of this precaution will quickly and *permanently* lower the efficiency of the air cooled burner.

It is essential to allow burners to burn five minutes or more after lighting before starting a treatment.

Eliminate a variable factor by keeping the cooling of the lamp as nearly constant as possible.

A minute-inch technic for ultraviolet lamps cannot be given because of variations in different types and makes of lamps, voltages, age of burners, etc.

Solid quartz rods (when clear) are better transmitters than hollow, air filled, quartz-tipped applicators.

Shall we precede ultraviolet light applications with radiant light and heat? For intensifying local reactions; yes. In general applications; no.

Most failures in dermatology from use of ultraviolet light are due to incorrect technic, poor apparatus or timidity.

Where the purpose is to *produce a violent reaction* nothing (except cleaning) should be done to the area before the treatment, such as cocainizing or adrenalizing; or after the treatment such as the application of sedatives or antidermatitis remedies which would prevent the full and prompt formation of

such reaction. If the operator is afraid of the reaction himself, he may be assured his patient will be much more terrified. Never fail to warn patients when you intend to produce a violent reaction and explain to them that it will be painful for a day or two. If he refuses to stand the gaff, then resort to the use of less painful (and less efficient) applications such as ointments, etc. This does not mean that the physician should be brutal. It is little short of deliberate brutality and may be quite dangerous to produce a heavy *third degree* reaction over a major portion of the body at one application. It is exceedingly rare where *heavy reactions over large areas* all at the same time are needed or justified.

CHAPTER XI

X-RAY THERAPY IN NONMALIGNANT CONDITIONS

Deep x-ray therapy is not touched upon in the present volume for many reasons. It is peculiarly a specialty in itself and requires much practical experience in the use of the x-ray before a man is qualified to undertake it. It requires long experience in the use of the x-ray for ordinary therapy and the deep x-ray therapist should have in addition a special course of training under some master of the subject before attempting it. It is no game for the novice.

This does not mean that x-ray therapy is forbidden ground to all but the experienced deep therapy experts. Of the total number of cases where x-ray therapy is indicated the percentage where only deep therapy will answer is relatively small—much smaller than the average physician realizes because he does not use ordinary x-ray therapy in more than a portion of the cases where its proper use would give him good results. I hold the x-ray so very indispensable to the therapist that I would not consider attempting to practice (private, group, hospital or clinic) without such an outfit. The man who divides his x-ray therapy dosages into three parts—stimulative, inhibitive, destructive—and uses it according to the indications for these divisions misses what for many years I have considered to be its most generally useful therapeutic field. This is what I have for the last few years designated as its ionizing effects—the diffuse but positive effects of very small dosages. Before adopting that designation I called the effects of these small dosages "solvent effects" and when it comes to a descriptive name I am not convinced but that the earlier term was the better one for that is exactly the effect produced by proper dosage. These effects are not so plainly evident where the x-ray is used alone as when used in conjunction with other physical agencies. One has but to have closely watched the results of the various combinations of physical remedies in the treatment of a large and variegated series of cases of asthma, bronchitis, functional heart disturbances,

pulmonary tuberculosis, etc., following the gassing of the service men, to be convinced of the absolute value of the x-ray when added to other treatment that was proving markedly palliative but which, without the x-ray, was unable to clear up the causative factors. When I say that some of these terrible bronchitis and asthma cases were so sensitive that the difference between three and three and a half milliampere minutes of x-ray once every five days was the difference between progress and comparative comfort and almost intolerable exacerbations, I am stating the simple truth. Every test was made to eliminate any psychic effect such as secretly sub-

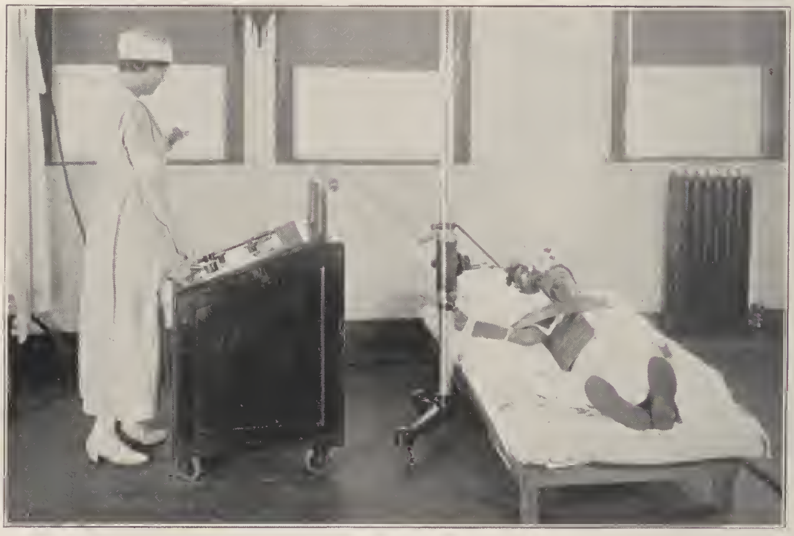

Fig. 46.—Low voltage ionizing x-ray therapy.

stituting layers of lead for the filter so that the patient and operator thought that he was receiving the ray when he really was not, etc., and when this was done he almost *invariably* volunteered the information that the last treatment did not do any good. No patient knew whether he was really receiving the ray in normal dosage, overdose or no dose at all and yet his reaction (or lack of it) followed the dosage so closely and constantly as to put it outside the pale of coincidence.

By an ionizing dosage is meant dosages smaller than stimulant doses. If attempt is made to test the value of x-ray on some of

the cases mentioned with heavy filtration and stimulating or larger dosage, failure is bound to result. When a roentgen therapist assures us that the application of x-ray is contraindicated in neuritis, for instance, because he has tried it many, many times with only bad results, we do not need to ask him what technic he employed. We know the one that he did not use. No series of cases was ever better adapted to show the effects of physical remedies than this series of gassed patients. Most of these cases had been in many hospitals and all had had every approved form of treatment (unsuccessfully, because the cases that responded to other treatment never reached our clinic) except the physical remedies. Some of them had had applications of a single physical remedy under the direction of a ward surgeon without effect and all were progressively becoming worse. Some of them were weak to the point of exhaustion from repeated and severe attacks of asthma and coughing. Not a few of them were already tuberculous, others were suspects and many others were drifting for that zone. Many had arthritis and severe wounds, osteomyelitis, etc., in addition to the bronchial damage. Some had Bright's disease and other complications. The wards housing these poor victims of the most damnable thing that was ever conceived in the mind of a human fiend were, with the possible exception of the violet ward for the worst nerve disorder cases (many of these from the same cause), the hardest wards in the hospital on the surgeons, nurses and attendants. The violent ward was quiet except at the times when some disturbance precipitated a general outburst, but these wards were *never* quiet, day or night.

These patients came for treatment sullenly, because ordered, and were firmly convinced that only "some more experiments" were to be done upon them. Indeed, at first, many of them flatly refused to submit to any treatment at all in the physiotherapy department and the first cases we treated were those that were already so miserable that, as one poor fellow remarked between gasps after we had explained the rationale of the proposed treatment to him, "Go to it! If you can make me any more miserable than I am now maybe even that change will be a relief." This particular patient had been gassed three times with two different gases and was having an average of sixteen severe asthmatic attacks a day and was coughing night and day except when full of an anodyne

cough mixture, was weak, irritable, emaciated and hopeless. His asthmatic attacks dropped to an average of three a night (none in the day) after *less than a week's treatment* and these attacks were very mild and short as compared to his previous ones. His case history shows that after the third day he was only given a single dose of the cough mixture at bedtime to prevent possible paroxysms in the night (repeated heavy doses had not prevented them before). Months of treatment were necessary to cut these attacks down to an average of one every ninth night. After the first week his gain was slow but perfectly steady. He became ambulant the first week. Many other similar and less severe cases made a like improvement, some of them being entirely freed from symptoms. On the other hand, some apparently less severe cases responded only slightly. In no case was there any retrograde movement. All showed *some* degree of improvement. The general average of the *great majority* of these cases was one of rapid improvement at first and slow but steady improvement in later weeks. After the treatment became general the very much changed atmosphere in these wards was a subject of remark at the staff meetings. When the x-ray outfit (at first we had only one therapy machine—later we were given three) went out of order for more than a week, the change in the whole series was plainly evident. A review of the symptomatic medication on the wards showed an unfailing large increase at such periods although the diathermia, static condenser, actinic and other prescribed treatments *were kept up* right along. Cases of gas bronchitis treated with the x-ray alone showed palliation but little or no real progress. So to the x-ray must be given a large share of the credit for the real improvement that took place in most of these cases treated.

To have such a demonstration as was made on these gas derelicts—and made against such odds—dismissed with an airy wave of the hand and the remark ''Psychic, purely psychic'' as was done in our presence by a very pompous and noted consultant evoked such a reaction of nausea in us that we did not even retort. Such ignorance—even of *psycho*therapy—in a man *pretending* to be a therapist, and a *consulting* therapist at that, shows why much of our therapy is now in the hands of quacks and irregulars who, no matter what their other shortcomings, excel *him* at two most important points.

They are not blinded by prejudice and they do not make the mistake of *trying* to sell the public something that the medical profession itself has pronounced worthless—*negative* therapy. It used to be the case that doctors prescribed for their patients, but due to the most liberal education along therapy lines that this same public has received from the medical profession (literally) they now with increasing frequency prescribe for their doctors by refusing to accept and pay for any treatment that well informed, honest medical men admit is of about the value of a placebo. The few men who *persist in spite of all proof* in attempting to read the most positive factor in therapy—physics—as "psychic"—are too myopic to be trusted with the steering wheel very long. They had much better correct their vision while there is yet time.

I am not going to cover all the ordinary uses to which the x-ray can be put in therapy. The literature is full of the descriptions of these uses and the technic. I much prefer to emphasize a very broad field that is in danger of being overlooked in these "20 inch" x-ray days. Any one having *any kind* of a transformer or self-rectifying outfit and Coolidge tube can use these dosages. A good meter and a Coolidge tube control (for stability) are requisites. There is too much variation in quality and quantity of x-ray when attempt is made to do therapy with the ordinary gas tube, and a high frequency-gas tube outfit for *x-ray* is our idea of inefficiency personified. I believe all who have had experience along this line will agree to this. Even the light units for fluoroscopy will answer for these dosages provided control and meter are accurate. Very excellent x-ray outfits having a surprising range are now on the market at low prices, quality considered.

One of the most astonishing things that I observed in all my x-ray-ultraviolet ray clinical research was the increased efficiency of much smaller x-ray dosages when used in conjunction with other physical agencies such as the ultraviolet, conversive heat, static condenser discharge, etc. The constant tendency as I progressed was to use smaller and smaller dosages of the x-ray and intensify this dosage with one of these other agencies. The work naturally led me to experiment with stimulating and substimulating dosages of the x-ray upon the various internal secretion glands but this work was done under stress of carrying on in a huge clinic and this gave me no time to follow out the researches suggested to their

logical conclusion. During this work I became acquainted with Dr. Chas. F. Stokes and his specialized research in the field of what he has so aptly named "Selective Electronization" which he had been carrying on for some time. His recent résumé of his research up to the present time is so well worked out in detail and so nearly exactly coincides with my own experience at many points that I have asked his permission to include it in this chapter and he has kindly consented. This research has not yet been published but probably will appear in the official journal of the New York Electrotherapeutic Society, *The American Journal of Electrotherapeutics and Radiology* before this volume is off the press so that I acknowledge previous publication to that journal. I wish to acknowledge our gratitude to Dr. Stokes and his constant research assistant, John F. Stokes, his son, both for the privilege of including this research here and for the many delightful hours that I have spent in their clinic watching their work and discussing the various angles of the subject.

THE TECHNIC OF SELECTIVE ELECTRONIZATION*

By Charles F. Stokes, A.M., M.D., D.Sc., LL.D., F.A.C.S.,
Former Surgeon General United States Navy and
John F. Stokes

Two years ago, in a discussion at the New York Academy of Medicine, I gave out the hypothesis on which this research is based. The hypothesis is substantially the same today, and is as follows:

In my research of recent years with the x-ray I have assumed that electrical equilibrium, or preferably electronic equilibrium, in the human cell structure is a natural and normal condition indicating a state of health in that structure; and that any upsetting of this equilibrium except through normal physiological excitations and transmissions, means an unnatural or abnormal condition indicating disorder or disease, as the case may be. In the use of the term "electrical equilibrium" I assume, in line with the electron

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theory, that all forms of matter are exhibitions of electrical phenomena.

Without going deeply into the generation of x-rays, I would like to call attention to the recent important discovery of a reciprocal action when x-rays strike any substance. The blast of electrons in the tube on striking the target gives over its energy to the energy of x-rays, and the x-rays in turn, on impact with any substance, turn over their energy into the energy of moving electrons.

Sir William Bragg in his Kelvin-Lecture of two years ago remarked that dependent upon the penetrative power of the x-ray, and dependent upon further research of x-ray frequency, the possibility of the x-ray furnishing the means to restore electrical equilibrium, or health in cell structure, is clearly indicated.

In coining the term ''electronization,'' I have striven to emphasize the point of using, in treatment, radiations of suitable wave length, and dosage so small as to affect the groupings of electrons in the atomic structure of pathologic cells only, cells that have lost, or have parted with, sufficient electrons to disturb their equilibrium. Such cells, groups of cells, and organs, in a state of health should be able to maintain an electronic equilibrium except as it may be varied in response to excitations and transmissions within normal ranges. To electronize a tissue, the electronizing dose should be so minute that it will not seriously disturb normal tissue cells, and yet be sufficient to equilibrate or rejuvenate, of course with obvious limitations, abnormal organs. Pathologic tissue has been shown to be positive in charge, probably by reason of disturbances in the outer shells of its atomic structure, whereby negative electrons have been parted with,—they in turn accomplishing less stable groupings. If this biophysical picture be true, then we, by electronizing such a field, may accomplish selective electronization, if the pathologic tissues take on, in the outer shells of their atomic structure, sufficient negative electrons, knocked from unstable groupings, to enable them to resume or approach their former equilibrated condition.

During the past two years many contributions to the literature of biophysics are in line with the hypothesis given above, and much of importance in biochemistry and biology, is confirmatory. The consensus of opinion seems to be that the primary factor in

protoplasmic and cellular function and structure is electrical, followed by chemical and physical changes, varying in kind and degree from the physiological phenomena of electronic equilibrium to the gross pathologic lesions of electronic imbalance. For example, I am in accord with Mackee, when he discards the lecithin hypothesis, the chromatin hypothesis and the enzymatic hypothesis, and favors disturbances in atomic structure in explanation of the effects of radiations on normal and pathologic tissues. X-rays and gamma rays (which are identical with the exception of differences in wave length) when given in destructive doses, presumably split off electrons from the outer shell of atomic structure, thereby inducing gradual chemical and physical changes that ultimately cause cell disintegration, or cell death. The latent periods, after heavy ultraviolet light exposures and destructive x-ray radiations followed by so-called burns, may be accounted for in some such way. The more sensitive cells gradually succumbing, others becoming permanently damaged, all resistant to remedial measures. Of course, such changes would be gradual and the first gross manifestation after the latent period would be an erythema. The freed electrons probably form new and unstable groupings, playing havoc with local chemistry, structure and function. Ultraviolet light as a prophylactic and for remedial purposes in these cases is distinctly helpful. Ultraviolet light frees electrons from unstable groupings.

The contrast between the behavior of colloids in the presence of electrolytes in bulk and in small quantities resembles in a way the reactions of the tissues to heavy and diminutive doses of x-rays. For example, a quantity of electrolyte when added in bulk will cause complete precipitation of suspensoids; when added in small quantities at a time will be ineffective in disturbing electronic conditions in the colloidal aggregates. Electronic equilibrium in living cells is so delicately adjusted that when out of balance in pathologic conditions only diminutive doses of x-rays, or other radiations, are likely to be reconstructive. Heavy doses such as are ordinarily used in x-ray therapy would probably defeat our purposes and are naturally contraindicated.

Crile and his coworkers have made exhaustive studies in biophysics and biochemistry. I am quoting from one of their recent contributions to the literature to stress further the importance of

using diminutive doses of radiations; doses far below those having inhibitory or stimulating effects.

"Every organic cell consists of two distinct parts—a nucleus and a cell body. The nucleus and the cytoplasm of the cell body require different stains—the nucleus being acid, and the cytoplasm being basic or alkaline. The cell is bounded by a lipoid membrane, a little surface film of lipoid material, and the boundary of the nucleus also is a thin lipoid membrane. These membranes are selectively semi-permeable, that is to say, each permits certain ions to enter and to pass out of the cell or the nucleus. The mass of the cell as a whole is made up of colloidal material. If the selective semi-permeable membrane is destroyed, the cell as a functioning unit is destroyed. If one destroys the membrane, the cell dies; that is to say, these membranes are absolutely essential to the life and function of the cell, and the cells in turn are essential to the life and function of the animal or man. These histologic observations are in accord with the findings of Sir Frederick Mott and of other investigators.

"Whenever the physical change, either in the nucleus or in the cell body, has progressed to such a degree that they no longer stain differentially, the cell cannot do its work—it is dead. In order that the cell may function and live, why is it necessary that the nucleus shall remain acid, and the cell body shall remain alkaline, and that the thin intervening membrane shall remain semi-permeable? Because—and now I come to theory alone—the cell is postulated to be an electro-chemical mechanism. Its life and function are dependent on the maintenance of a difference in electric potential between the nucleus and the cell body. In accordance with this conception the discharge of a cell is like the discharge of a battery—the cell, like the battery, becomes exhausted. Life itself is dependent on the maintenance of this difference in potential, or, as the physiologist would say, the maintenance of the acid-alkali balance in the body; but when physiologists speak of the acid-alkali balance of the body they really refer to the acid-alkali balance between the cell body and the nucleus." (Crile.)

An interesting phenomenon depending on surface tension occurs when the protoplasmic contents of a ciliated infusorian is pressed out in water. A new membrane forms on the protoplasm because of surface concentration of all constituents which lower surface

energy. By application of the principle of Willard Gibbs, A. B. Macallum concludes that not only absorption, as exhibited in a colloidal solution, but also the local accumulations of material often seen in cells, are associated with changes in surface energy. His conclusions are based largely on microscopic studies of various forms of cells exhibiting different degrees and types of activity, and ingeniously stained for potassium by cobalt hexanitrite. By such a means the potassium stains intense black. In vegetable cells, local accumulations of potassium occur either near the interface between the clear and the chlorophyll-containing parts of the cell (spirogyra) or under a portion of the cell wall from which later a protrusion grows out to form the first stage in conjugation. The outgrowth from the cell, as well as the accumulation of the potassium, may be the result of a low surface tension. In unicellular animal organisms, such as Vorticella, much less potassium is present, being confined to the base of the cilia, which Maccallum believes indicates that the structures are produced as an outcome of low surface tension.

In the cells of higher animals, deposits of potassium are also localized; in striated muscle, for example, they occur in a zone at each end of the doubly refractive band and immediately adjacent to the singly refractive band. Changes in surface tension, associated with changes in the distribution of potassium, are believed by many to be responsible for muscular contraction. In nerves and nerve cells, potassium is concentrated at the axon and at the surfaces of the cells. Interesting suggestions are offered to explain the relationship among changes in surface tension at the terminations of axons (synapses, terminations in gland and muscle cells) brought about by the nerve impulse acting as a change in electric potential. Surface condensation of potassium has also been observed at the lumen border of gland cells (pancreas), and on the lumen surface of the cells of the renal tubules. Such observations indicate in what way surface tension may be called into play to control cellular activities. The field is new and almost unexplored, but there is already much to indicate that surface energy plays a most important rôle in the performance of many cellular activities. (Macleod.)

Burns and others have found that of the 12 to 15 elements essential to life, potassium alone possesses distinct, if minute, radio-

activity, and by reason of its emitting negative electrons it is an essential constituent of every living cell. The radioactivity of potassium according to Burns is known to have at least two effects:—

1. Because of their velocity B-rays (electrons) accelerate the rate of migration of gaseous ions in a similar way to ultraviolet light of extremely short wave length (below 2000 Angström units) i. e., the ionized gas becomes a better electrical conductor.

2. On account of its unit negative charge, the B-ray (electron) has a disturbing effect on all systems in electrical equilibrium through which it passes.

The universal distribution of radioactive potassium, in living cells, is very significant.

It is known that fluorescent substances exert sensitizing effects in plants and animals and that those rays of light are most effective which excite the strongest fluorescence. Chlorophyll, for example, in some manner, still imperfectly understood, is enabled to produce starch from carbon dioxide and water in the leaves of plants in the presence of light. Infusoria when placed in contact with an extract of chlorophyll, made from green leaves, and exposed to light, quickly die, while if kept in the dark, they show no alteration. Cultures of infusoria behave the same way when exposed to red blood corpuscles.

Of the porphyrins, perhaps the most important is hematoporphyrin, derived from hemoglobin but distinguished from the latter by its lack of iron. It is fluorescent and is a sensitizer, having the same effect upon infusoria in the presence of light as chlorophyll and red cells. Small amounts injected into mice, so long as the mice remain in the dark, appear to be without effect, but when the animals are exposed even to diffused daylight, they soon begin to scratch at the points of injection, grow restless and agitated and finally perish from exhaustion.

The universal distribution of hematoporphyrin as an essential content of living cells speaks for its importance; still just how it acts we do not know. It may have a regulatory effect on the emission of elections from radio-active potassium, as the grid of an audion regulates the emission of electrons from the heated filament in response to radio or Hertzian waves.

Ingvar has made some very illuminating observations which I

take the liberty of quoting in order to call attention to the diminutive currents used in this work to simulate physiological currents in embryos:—"By applying a weak constant galvanic current (strength 2-4 billionths of an ampere, density approximately 1/1000-1/2000 delta, nonpolarizable electrodes) to tissue cultures made according to Harrison's method, the following observations were made:

"The galvanic current has a direction influence upon the cell and fiber outgrowth in the culture, so that this occurs almost entirely along the lines of force in the galvanic field. Whereas in the control preparation the outgrowth occurs in all directions, cell movements under the influence of a galvanic current take place toward the anode and the cathode. The cell processes growing toward the anode show morphological differences from those growing toward the cathode. A new biological cell character may, in this way, be revealed.

"If a weak electric current by means of a single conductor is drawn through the culture, the outgrowth of the fiber and cells always takes place perpendicular to the conductor. Bok has called attention to the fact, that in the living organism, the nerve fibers grow out from the spinal cord perpendicular to the long fiber paths growing down from the brain stem. Kappers has tried to explain this as a galvanotrophic phenomenon. To this observation, an interesting analogy is thus found in the tissue cultures.

"The hypothesis of Kappers, as the main result of this author's work on 'Neurobiotaxis,' that electrical forces are determining factors in the outgrowth and distribution of the different constituents of the nervous system, has been proved to be a fact in pieces of the central nervous system of the chick culture in vitro.

"As several authors (Hyde, Mathews and Pfeffer) have pointed out, electrical currents flow in developing organisms. The current successfully employed in these experiments corresponds in range and electromotive force with those found in various embryos. From this it may be concluded that electrical forces play an important rôle in the formation process in morphogenesis."

Loeb has shown that animals move adaptively in response to light. Piper has demonstrated in fish the presence of electricity in the auditory nerves as a consequence of sound waves. Steinach by replacing the otolith in the auditory sac of a fish by a piece of

iron of similar shape, confirmed his belief that the hair in the sac was the receptor mechanism, by bringing a magnet to bear upon the iron thus changing its gravity relation to the hair, inducing the fish to execute erratic movements. Einthoven and Jolly have demonstrated that electric currents appear when a ray of light falls upon the retina. (Bayliss.)

The evidence is in favor of electrical factors being basic in physiological processes and if basic in physiological processes, then surely they must be so in pathologic processes. Alvarez has shown that if two regions with different oxidative rates are connected to a galvanometer, the more actively growing or more mobile one is always electronegative to the other: In the wire the electron current flows away from it. In the tissues, of course, the electron current flows from the less active end of the metabolic gradient to the more active end. Growing root tips of seedlings are negative to other parts of the root. The growing tip of the plant is electronegative to all other regions. Child and his students have found gradients of electric potential along all the axiate animals and plants which they have studied. In the electronegative field oxidative processes are relatively more active, which is significant. We are just beginning to see that these minute differences in electric potential play a large part in development, physiology, pathology, in fact, in all the life processes of the organism.

Child of the University of Chicago, through his physiological gradient conception, has given us a biologic approach of inestimable value, to the elucidation of many problems in embryology, physiology and pathology. In his experiments with planaria he was able to develop a head-end at any point in a segment of planaria by increasing the metabolic rate at that point through excitation. Where the metabolic rate was highest there the head-end developed with a falling metabolic rate along the gradient down to a tail-end. Lillie has found that electrical and oxidative gradients coincide and Tashiro has pointed out a coincident gradient for carbon dioxide.

The first factor in the development of gradients in protoplasm is electrical, the second chemical and the last physical; these responses are brought about by contacts of protoplasm with factors in environment, the beginning of the excitation-transmission phenomenon. Once established, metabolic gradients bring different

regions within their range into definite physiological relations, and differences in electrical potential, found to exist between different levels, afford a definite means of actual correlation.

As soon as differences in protoplasmic constitution appear at different levels of a gradient, chemical or transportative correlation develops; in other words, the primitive endocrine system is evolved at this time. Later, various other mechanisms of correlation are developed, such as the vascular systems, the supporting and other mechanical tissues, the organs of secretion and excretion and in most animals, the nervous system, the organ of integration par excellence. Each of these great systems is evolved on the physiological gradient pattern, as for example, the brain is the head-end or apex of the nervous system; the stomach, according to Alvarez, is the head-end of the digestive gradient; the lungs, the head-end of the respiratory gradient, and the pituitary, as pointed out by me, the head-end of the endocrine gradient. In correspondence, Child was kindly disposed to this endocrine gradient conception. It is often difficult to trace visible connections in gradients in man and the higher animals, as avenues of communication frequently lose their identity through differentiation, yet it is believed these avenues of communication are never entirely lost. For example, most biologists are agreed that the appearance of a nervous system in protoplasm does not involve the origin of a new functional activity, different from the fundamental activities of protoplasm in general. The current view is rather that nervous function develops in some way from the functions of excitation and transmission, which are characteristic of all protoplasm. If this view is correct, some sort of physiological continuity must exist between excitation and transmission in general and the development and function of the nervous system, yet it is not demonstrable. (Child.)

As far as I know, the part played by radioactive potassium in cell structure and function has not heretofore been postulated. If researches in radioactivity during the past twenty years have revolutionized chemistry and physics, surely it is time the electron theory were taken seriously in biology, physiology and pathology. How can we comprehend physiological and pathological processes if we ignore the basic factors underlying them?

If we accept the pituitary gland as the head-end of the endo-

crine gradient then we can possibly understand the interrelations of the ductless glands although visible continuity may not be demonstrable. It is significant to note in connection with the endocrine gradient conception, that Hirsch by x-raying the pituitary gland from two fields, using a 60 per cent erythema dose, was able to produce a prompt inhibitive effect on metrorrhagia. In fifteen myomas, which were subjected to this treatment, unusually prompt retrogression occurred; the time was much shorter than had been required to accomplish this by ovarian irradiation. In four weeks the myomas often decreased from the size of a child's head or a fist to the size of a walnut. While no bad effects or disturbances followed this procedure in Hirsch's hands, he wisely advises against its use in growing organisms. He is using an inhibitive dose thereby probably inducing permanent changes in atomic structure.

The ductless glands are generally conceded to be the regulators of metabolism and it is fair to assume that the pituitary gland as the head-end of the endocrine gradient, is active in the regulation of metabolism in the brain and its various receptor mechanisms, cooperating no doubt with other ductless glands.

The infectious diseases, focal infections, psychic shocks and such stresses as childbirth put a heavy load upon the endocrines and are frequently followed by disturbed metabolism, general or local, often persistent. For example, in infectious diseases we commonly see coincident or subsequent infections in the nasopharynx, eustachian tube and middle ear, suggestive, by reason of their tendency to chronicity, of continued lowered resistance in these fields. Furthermore, we have noninfective lesions, also suggestive of disturbed metabolism. How are we to correct these disturbances in the endocrines? Are the gland products as medication really basically remedial? Harvey Cushing recently said that he believed the pituitary would one day be effectively treated by some sort of radiation. Can we successfully treat the end results of deep pathology if we do not give thought to basic conditions? The procedures suggested in this paper supplement and in no way supplant accepted practice in the treatment of end organ lesions.

I shall confine my remarks to electronization of the pituitary region, as the head-end of the endocrine gradient, although these methods are applicable to other fields. The pituitary gland is

surrounded by the Circle of Willis, and is flanked on either side by the two terminal internal carotid arteries, perhaps the richest circulatory field in the body, and communicates through the infundibulum by way of the third ventricle with the great ventricular system of the brain and cord. Authors are not in full accord as to the functions of the pituitary gland. One or two doubt even the communication through the infundibulum with the ventricular system as outlined above. Sajous regards the posterior pituitary the center for the sympathetic system and there is much to support this contention. He is very firm in the belief that one of the important functions of the pituitary is the destruction of toxins.

In young ascidians, in amphioxus, and in some other low forms, the primitive pituitary, or test organ, has distance receptor functions, in part, and may be regarded as the forerunner of the special sense fields, although in man visible continuity is difficult to trace except perhaps in the case of the ear where the cochlea is in direct communication, through the aqueductus cochleae, the aqueduct of the perilymph, with the subarachnoid space and the great ventricular system.

It is fair to assume, at any rate, from its anatomical position alone, that the pituitary has to do with the metabolism of the brain and its distance receptors. The metabolic rate in the brain is the highest in the body.

Pathologic tissue is positive in charge in relation to neighboring normal tissue, that is, it has lost electrons. When the pituitary gland is involved the secondary effects are likely to be far-reaching and, conversely, effective remedial measures should be generally beneficial. I have repeatedly seen this confirmed clinically. When the blood sugar content is high after electronization it tends to fall; when low it tends to rise. High blood pressure tends to fall; low blood pressure to rise. In the majority of cases the fall is permanent. In frank arteriosclerosis the fall is slight, otherwise the effect would be that of depression and hence undesirable.

While electronization has been of conspicuous benefit in many conditions, other than impaired hearing, such as epilepsy, infantile paralysis, anosmia, hypertension, neuralgia, convalescence

from infectious diseases, etc., I shall largely confine my remarks to the pituitary-auditory field in describing the technic. This method has established its worth as a remedial procedure, if properly employed; but it is by no means a cure-all and it has its limitations.

Pathological conditions in the nasopharynx should receive such surgical and other treatment as may be indicated for the removal of infected tonsils, the establishment of proper ventilation through the nares and the like.

It is not my intention to discuss results at this time. Later you will probably hear from aurists who are using these methods in their practice. In outlining the technic, however, I cannot too strongly emphasize the importance of using a particular type of machine and tube. I have tried out six or seven different types of apparatus and the results have been satisfactory only when the apparatus about to be described is used. The physicists have been unable to explain this phenomenon.

The heart of the treatment is the x-ray. The type of x-ray machine is vital to success; this, I have learned from expensive experience. The machine should be one which energizes the x-ray tube with an alternating current of comparatively low x-ray voltage, approximately 50 K.V. The alternating current should not be mechanically rectified. In using self-rectifying tubes, radiator type, and this type of tube should be used, energized by alternating currents, it is impossible without the use of elaborate instruments accurately to determine the voltage, because the transformer is unbalanced; in other words, but half of the current of each cycle becomes effective in producing x-rays. Although this be true, it is safe to rely upon the estimated voltage or the secondary voltage, which the manufacturers designed the transformer to produce, in estimating the maximum effective voltage, as it is not likely to greatly exceed this amount. The General Electric Company calibrated a disc rectified unit, which we have, with a large sphere gap and found the kilo voltage to be 57, set as we use it. This machine has been so altered that rectification now takes place in the tube, but it is safe to assume that maximum effective voltage, at the same

autotransformer setting, cannot differ widely from that measured by the sphere gap.

This corresponds roughly to a 4 inch spark gap depending upon atmospheric conditions. A 3 millimeter aluminum filter is used; distance from target 30 inches.* The auditory and temporal regions on both sides are exposed to the rays for from 25 to 30 seconds through a 3 inch aperture in a lead-leather screen. The rays are then directed through the open mouth toward the sella turcica, sweeping through the nasopharynx, thyroid and adjacent tissues 20 seconds. The eyes are screened. Lastly the rays are directed through the occipitocervical region with the head slightly inclined downward 20 seconds. This is the only treatment given at the first visit. I have found that the best results are attained by giving from ten to twenty treatments at short intervals, daily, if possible. The dosage is well under $1/50$ of an erythema dose. I have been assured by competent physicists that this dosage will not materially affect normal cells, and yet I have demonstrated clinically to the satisfaction of at least two competent physicists, that certain pathologic conditions are affected favorably. This is just as we would have it. Turrell says that in clinical practice we use x-rays for three distinct purposes: (1) for stimulation; (2) for inhibition of restraint; (3) for complete destruction of cells. In electronization, we neither stimulate, nor do we inhibit, and certainly we do not destroy. What we accomplish is more in the nature of rejuvenation, or equilibration; we restore the acid-alkali balance in cell protoplasm, and as might be expected, barring unforeseen accidents, the results in the majority of cases are relatively permanent. In over 30,000 treatments I have seen no untoward result worthy of mention.

The patients are given a general overhauling, their hygiene investigated and corrected, if possible, and if necessary are referred to an operating aurist for surgical conditions. Many show evidence of endocrine imbalance, others are mildly toxic and frequently the colon is at fault. These cases are referred to Schellberg for cecal irrigation and the establishment of proper

*Dr. Stokes always regulates the control so that (8) eight milliamperes are passing through the tube. (Sampson.)

drainage in the digestive tract. This last is followed by the use of the Morse Wave Generator.

At the second visit the x-ray treatment is preceded by mild diathermy through the auditory regions (it has been found that 1° C. rise of temperature increases conductivity 2½ per cent, oxidation 10 per cent and makes x-rays more effective) followed by mild high-frequency, nonvacuum electrodes in auditory canals (cell stimulation). This is followed by inflation with a nebulizer. I have long since discontinued the use of the catheter. If I fail to get through at first, the eustachian tubes usually open up later. (X-rays resolve connective tissue deposits in the epiblast.) The next step is mild pneumo-vibration through the index finger, which is inserted into the external auditory meatus. At this point various other measures are employed, if indicated, such as vibration of the region of the vertebra prominens, or high frequency in that region, or both, or the diathermic massage of Turrell. In the chronic catarrhal cases ultraviolet light, water cooled lamp, quartz applicators, are used in the nares, or pharynx or both. (Ultraviolet light destroys bacteria.) The quartz applicators are sometimes used in the auditory canals. Where there is stiffness, soreness or a possible neuralgic condition, the deep therapy lamp is used. Then follows the x-ray treatment, as outlined above, and the sitting is completed by an exposure to the air cooled quartz lamp of 40 seconds on each side of the head. (Ultraviolet light increases the tolerance of the skin to x-rays.)

In preparing this paper I have yielded reluctantly to repeated requests for technic, knowing full well that the research is far from complete. I have, however, endeavored to point out the part played by biophysics in morphogenesis, physiology and pathology, and the importance of using diminutive doses of x-rays has been stressed. The dosage should be far below even stimulating radiations, the object being to reach selectively the atomic structure of pathologic cells and to leave undisturbed normal cells, which is in line with the prophetic words of Sir William Bragg noted above. The treatment has been shown to be free from harmful effects and, as might be expected, when properly given and faithfully carried out, when results are obtained, they are generally lasting.

CHAPTER XII

ULTRAVIOLET AND X-RAY AS PHYSIOLOGIC COMPLEMENTS IN THERAPEUSIS: A NEWLY ESTABLISHED CLINICAL TREATMENT*

In provinces other than the province of medicine the method of scientific advancement is preeminently that of deductive sequel.

When the method of the scientific laboratory is applied to the study of the human organism, it is sometimes observed that the physically deduced laws either do not obtain, or obtain in so modified a form contrary to expectation, that the results are no longer recognized as born from the parent observation.

A critical survey of accomplishment in medicine points strongly to the fact that medicine is not a science as compared to the ordinarily accepted concept of physical science. In truth, medicine is an ultra science whose phenomena are myriad and defiant of ordinary scientific standards. The explanation seems to lie in the exceptionally complex structure of the human organism, a structure infinitely more complicated than even the most complicated inanimate object; and added to this already intricate organization, there must be considered that inevitable something called life for which no scientific explanation has ever yet been satisfactorily adduced.

Hence progress in medicine can be expected best along the lines already set by precedent; namely, empirical observation serving as a basis for the deduction of law, rather than law serving as the basis from which to experiment for a desired result. After all, the method of medicine is statistical. Observations are first gathered, then sorted and classified into similar groups. Finally, they are given to the laboratory scientist with the view of establishing the fundamental structure underlying the empirical observations.

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*MSS. submitted in Leonard Prize Competition. Published in *The American Journal of Roentgenology,* September, 1922, p. 570.

There is no "scientific" theory to offer in explanation of the clinical facts presented in this paper. There are some scientific precedents referred to, from time to time, which tend to show that these empirical results have somewhere a correlated precedent in medical observation.

The apparatus used is simple, the application is without difficulty, and the clinical results are instant. The basic theme is essentially borrowed from nature. The actinic rays of the sun impinging upon the peoples of a world, become necessary for the fit survival of those inhabitants. Fit survival implies natural prophylactic measures and natural curative measures. Local actinism, therefore, increases the effects on the skin at the point applied, similarly as solar actinism is manifested on the peoples of the world. It is well recognized that solar actinism was necessary for the protection of people closest exposed to the sun; and the result was that a permanently sun-burned or dark race was perpetuated. The empirical observations of this research make use of this phenomenon which has been constantly observed.

A comparative study of x-ray and ultraviolet-ray dermatitis reveals several very important differences. An x-ray dermatitis comes on rather slowly, usually in from eight to fifteen days or longer, while the ultraviolet ray dermatitis comes on rapidly, generally in from three to twenty-four hours. The x-ray dermatitis causes the hair to fall out, and, if severe enough, is followed by permanent alopecia. The ultraviolet ray dermatitis—no matter how severe unless compression has been used and the skin destroyed—checks the falling out of hair, stimulates the hair follicle, causes extra rapid growth of normal hair and often causes lanugo to take an added growth, size, and in some cases, pigment. The stronger the actinic ray reaction, the more stimulating it is to hair growth, one or two good ultraviolet ray erythemas usually being sufficient to arrest the falling out of hair even when due to heavy x-ray dosages. The x-ray dermatitis, if severe enough, is followed by atrophic changes, ulcer formation, sloughs, or telangiectases. The actinic dermatitis—no matter how intense the overexposure if compression

has not been used and the burner has been kept far enough from the skin to prevent a heat burn—is followed by desquamation or blisters, if the overexposure has been great enough, and the formation of new skin normal in every respect. An x-ray dermatitis increases the irritability of that area to subsequent x-ray doses, while the inflammatory reaction following heavy actinic dosage decreases the irritability of that area to subsequent applications of the ultraviolet ray. By means of rapidly repeated erythemas from the actinic ray, an area of skin may soon be in such a condition that it will require some fifty times the original dermatitis dose of the ultraviolet to produce even the mildest grade erythema. This increased tolerance of the skin to ultraviolet rays is not confined to the action of the actinic rays alone, but includes, to a lesser degree, the x-rays. Whether this increased tolerance is due solely to the tanning produced, or whether the repeated inflammatory reactions produced by the actinic rays cause the skin to lose some of its irritability, or whether the blood-chemistry changes which follow the application of ultraviolet light have an antidoting or damping effect upon the cycle of tissue changes set in train by massive x-ray dosage, cannot be stated positively at this time. Clinical evidence would seem to show that all three factors have a part in the increased tolerance. Surfaces tanned gradually by exposure to sunlight or weak applications of the actinic rays without noticeable erythema being produced, show a slightly increased tolerance to x-ray dosage, but nothing like the increase caused by repeated heavy erythemas, rapidly produced, by the quartz mercury burner. This increased tolerance seems to follow whether the surface tans or not, but possibly not to so great a degree where tanning does not take place.*

Case IV, while only a basal cell type, is included to illustrate this point. This patient's skin blistered easily, but refused to tan under the most rigorous actinotherapy, yet the reaction—or rather lack of reaction—following the roentgen-ray dose was the same as in the other cases. This holds true with all other

*The tanning of the skin is only one—and in our opinion one of the least—factor, and the subsequent vigorous actinic treatment applied after the heavy x-ray dosage is much more important than the preliminary treatments.

cases of the same peculiar skin that we have treated so far. One man with a skin of exactly the same type that refused to tan after repeated heavy actinic erythemas, was given 50 ma. min. with a 4 in. back-up spark, 8 in. target skin distance, 1 mm. aluminum and 1 mm. flexible leather filter at one dose, for a general cheloidal condition of numerous gas scars over one side of face and chin, with no visible reaction; 44 men were given 45 to 50 ma. min. in divided doses in a three-week period with the same factors, with no trace of erythema in any case. Most of these men tanned well. Seven of them did not tan visibly. When attempting to explain *exactly* how the ultraviolet light applications may antidote the constitutional effects of massive roentgen-ray doses, we meet with difficulty from both sides. Although both remedies have been in use for a long time, and much is known of the clinical effects of each, little has been definitely ascertained in regard to the minutiæ as to how either produces its constitutional effects. There are almost as many theories as there are research centers. Hall and Whipple,[1] in a very instructive series of experiments with the effects of massive x-ray dosages upon dogs, discuss the constitutional effect, and state so succinctly the difficulties of drawing conclusions, that we shall quote from them.

"Lange maintains that the reaction is the result of an acidosis resulting from cellular degeneration or from increase in catabolic cellular activity. He submits no analyses of blood or expired air to support this claim.

"Edsal and Pemberton advanced a theory which we believe to be more nearly correct. They noted that roentgen rays sometimes produced a constitutional reaction which they ascribed to an acute intoxication. They state their belief, 'The tissue destruction accomplished by the roentgen rays undoubtedly involves chiefly tissues especially rich in nucleoprotein. The decomposition products of this form of protein are especially rich in substances that are more or less toxic and difficult to metabolize and excrete.'

"This general systemic reaction which may follow the use of roentgen rays in therapeutic doses has another appeal to the

investigator. This reaction must be *'non-specific'* as no group of bacteria can possibly be concerned. If any injurious substances are formed in the body, these substances must be formed from the body tissues or fluids and not from any protein substances introduced. It seems safe to assume that the body protein must be injured in some fashion, as there is a distinct increase in urinary nitrogen and in the nonprotein nitrogen of the blood. In fact, the primary injury may react upon the body protein in some manner so that the tissue autolysis of the injured protoplasm may form toxic split products* which cause further injury to the body protein—a vicious circle.

"The question of ferments and roentgen-ray exposure is a most important one. When we finish the analysis of the anatomical changes caused by the roentgen rays and the review of the clinical symptoms of intoxication which may be due to the specific action of the roentgen rays on the leucocyte or the intestinal epithelium or the epidermis, we come up against the fundamental question: How do the roentgen rays injure a living cell? It is claimed by Hertwig that the chromatin is first injured and that this injury is the fundamental one. But Richards has shown that the cytoplasm is also injured. Many workers are tempted to leave the morphology of the cell and venture into the field of cellular ferments, which is equally difficult, to say the least. One must be very careful in accepting *in vitro* ferment experiments on unicellular organisms or isolated ferments to explain ferment reactions in the living complex of a warm-blooded animal.

"Yet there are observations which indicate that the body ferments in the living cells are actually influenced by the roentgen rays.† A spleen removed from a rayed animal will show more rapid autolysis than a control (Heile. *Ztschr. f. Krebsf.*, 1904,

*The validity of the split protein product theory is not generally subscribed to by the majority of immunologists nor by the writer; but the theme that seroprotein changes are involved is an established concept that requires no defense.

†Recent trend of investigation would point to the possibility of vitamine changes in x-ray and radium treatment. (See "Similarity of Effects Produced by Absence of Vitamines and by Exposure to X-Rays and Radium" by W. Cramer, A. H. Drew, and I. C. Mottram, London, D.P.H.). From the Imperial Cancer Research Fund, and from the Radium Institute, London. Lancet, May 7, 1921, i, No. 19, 963.

ii, 171). Our experiments indicate that the same holds for the epithelium of the intestinal mucous membrane exposed to the roentgen rays. A. Richards (*Am. J. Physiol.*, 1914, xxxv, 224; *Science*, 1915 xlii, 287), who has done the best experiments upon the roentgen rays and ferments, is able to show *in vitro* that small doses of the roentgen ray accelerate and larger doses inhibit certain ferment action. He does not believe, however, that this direct action of the roentgen rays on ferments is adequate to explain all the reactions of a living cell to the roentgen ray. This conservative opinion should have much weight.

"We should not lose sight of the fact that the roentgen rays pick out certain cells with no apparent rhyme or reason. Why, for instance, is the leucocyte injured and the pancreatic cells, which surely are rich in ferment escape entirely? Simple disturbance of cellular ferments by the roentgen rays cannot explain any such peculiar reaction as this just mentioned. There must be some initial stimulus or injury inflicted upon certain cells of the body and other body cells must be tolerant and escape this injury or stimulus. It is conceivable that the primary injury may form toxic split products which cause the final intoxication, but we have no right to assume this without some weight of evidence, and this experimental evidence has not been submitted.

"The word *injury* may be as good as any to indicate our belief that some change has been effected within the cell substance (nucleus or protoplasm). This change may influence, *first*, the cell protoplasm, cell lipoids, cell ferments, etc., but who is to say whether the structure or the ferment is first changed or injured by the roentgen ray? We know of many fundamental changes in cells, even fatal changes, which leave no trace that can be detected by modern histological methods. Yet we cannot accept such an instance without question as an example of *primary* injury to the cell ferments. We are too apt to cloak our ignorance by the use of terms which have very little fundamental significance when subjected to analysis.

"In the face of these difficulties the authors hesitate to outline the constitutional reaction to the roentgen rays as pictured in

their minds, and put forward this explanation with a proper regard for possible objections and criticisms. Exposure of a dog to the roentgen rays brings about certain changes (or 'injury') in certain of the body cells. In some cells the injury may be evident in a short time (leucocytes) and in other cells the injury may be greatly delayed (epidermis). We cannot explain this latent period. It is at least possible that other body cells may be injured after a longer or shorter latent period, depending upon the individual properties of the cells. The nitrogen elimination shows that the cell injury and autolysis begin promptly after exposure to the roentgen rays and continue with a rising curve to the fatal outcome. The blood nonprotein nitrogen speaks for the same progressive destruction of body protein. We have evidence that the ferments in certain cells of the body are profoundly altered and take part in the cell destruction beyond a doubt, yet we cannot say that this ferment disturbance is not secondary to some 'injury' of cell substance apart from the enzymes. There are individual peculiarities in the reaction of the cells to the roentgen rays which speak for an individuality in the cell reaction and this surely may not of necessity depend upon primary ferment change. The liver and pancreatic cells are rich in ferments, yet, so far as we know, they escape the roentgen-ray injury. The epithelium of the small intestine is closely related to the liver and pancreatic epithelium, yet it appears to be 'injured' by the roentgen rays. Is this due to a primary injury of ferments? Then how may we explain the immunity of other parenchyma cells which contain similar autolytic ferments?

"The obvious 'injury' of the intestinal epithelium offers a satisfactory explanation for many of the clinical features of the fatal intoxication—vomiting, diarrhea and prostration. Disturbances of this epithelium can produce a severe intoxication (intestinal obstruction) and for this reason we think the injury of the intestinal epithelium by the roentgen rays plays no small part in the general systemic reaction and intoxication."

Subsequent experimentation by Denis, Martin and Aldrich[2] offers further proof of the correctness of some of Hall and Whip-

ple's conclusions, but adds some very strong evidence in the behavior of the alkaline reserve curve* to the proof of the correctness of Lange's acidosis theory, which they were not inclined to favor.

In a series of studies on roentgen ray effects by Murphy, Hussey, Wakahara and Sturm, published in the 1921 volume of *The Journal of Experimental Medicine,* attempt is made to show the fallacy of many of the former theories, and to strengthen the lymphoid reaction hypothesis. Some of their conclusions based upon the experiments are very convincing. In Study No. vi, 301,[3] they state: "Hence it may be assumed that considerable doubt still exists that x-rays in a dose suitable for a living animal, i.e., an amount which will not produce a burn, will exert a very great destructive action on the cancer cell. The question arises why uniformly good results should follow the treatment of skin cancers, and almost as uniformly poor results be obtained in the treatment of cancers in only slightly deeper tissues. The problem involved is the immediate basis of the experiments to be described in this paper."

It was a recognition of the question so clearly stated above that impelled us to start our clinical experiments some two years ago, with a view both to increasing skin tolerance, and, if possible, finding some way to prevent or overcome the undesirable sequelae of massive dosage. With increased skin tolerance established, it may still be found that the increased dosage possible will not solve the problem, but that other measures, such as employing superheated air to induce a pronounced lymphocytosis,[4] will have to be used in addition to the roentgen ray and the ultraviolet ray. Again it may be found that the larger doses of a softer ray,[2] made possible by increasing the skin tolerance will help in the solution. It is admitted by most roentgen-ray therapists that the use of soft unfiltered rays in skin cancer gives results at least equal, if not superior to the hard filtered rays, and the smaller dose of softer rays—larger than formerly possible but still much smaller than the dosage of hard filtered

*Lewis (unpublished communication) points out the influence of psychic influences in affecting, to a slight extent, the alkaline reserve curves in aments. These slight changes would not appear materially to invalidate the conclusions of Lewis, Martin and Aldrich.

rays—while producing more local reaction, would not cause such a heavy reduction in the lymphocyte count, with the concurrent increase in susceptibility. This has been shown by Amoss, Taylor and Witherbee.[5] No matter from what angle the problem is viewed, the breaching of the stone wall of skin tolerance will allow entrance to new research fields.

A search of the literature serves only to pile up evidence for and against any given hypothesis, without definite proof either way. Any single set of experiments, no matter how valuable they may seem to be, can hardly hope to prove or disprove any given theory as to the exact action of the roentgen rays upon the body tissues. Until the evidence from numbers of research centers is in, and unless such evidence shows a preponderance of weight upon one side or the other, the explanations put forward may be said to be unproved as yet. This being the present status of the question as to why, exactly, certain reactions do follow certain doses of the roentgen rays, the proof as to how ultraviolet light antidotes any of these effects, or could operate in breaking up the cycle of changes following such massive dosage, could not be given (except clinically) even were very much more exact knowledge of the action of the actinic rays at hand than is the case.

The literature upon ultraviolet light, while fairly voluminous, is mostly clinical, and presents all the usual difficulties when attempt is made to draw conclusions from a sifting of the evidence. Edgar Mayer,[6] in a remarkably complete critical review of the literature on sunlight and artificial light in tuberculosis, most of which deals with ultraviolet light (his list of bibliographic references, printed in smaller type than the text and closely spaced, extends over more than thirteen pages and shows a wide search) gives some of his conclusions as follows:

"It is evident that we have yet many problems to solve. Some of these are: (1) The question of the exact mode of the formation of *pigment* and the actual rôle of this substance. (2) The proof of any specific powers possessed by pigment. (3) The ability or inability of pigment to change short rays to longer and more penetrating ones. (4) The relation of pigment to prog-

nosis and lymphocytosis. (5) The ability of pigment to set up focal reaction in tuberculosis.

"We require many more experiments to show the exact *penetrating powers* of the various rays, and additional data in relation particularly to the effect of violet and ultraviolet rays upon tissues, both healthy and diseased, and upon bacteria, especially *in vivo*.

"More experiments are needed to compare the effects of the ultraviolet rays with those of the red and ultrared rays, and many more comparative results between high and lower altitudes are necessary.

"From clinical experience with surgical tuberculosis, evidence points to the greater value of the ultraviolet rays, although it appears that the heat rays may also aid.

"Insufficient comparative and statistical studies upon patients, especially upon those with pulmonary disease, leave much to be desired.

"Much more knowledge must be had experimentally of the effect of light upon nontuberculous conditions."

Again: "The action of light on ferments and so-called 'antibodies' and other constituents of the blood, as well as its means of influencing the deeper organs, is mostly a matter of speculation up to the present. Its effect upon protoplasm is not well understood.

"The more important ultraviolet rays that affect cells, toxins, bacteria, ferments, etc., are present in the quartz mercury lights but absent in the sunlight as it reaches us."

The conclusion that the shorter the wave length of ultraviolet the more soluble it is in protoplasm and the more powerful it is in its effects, is expressed also by Bayliss[7] in his conclusions after his discussion of the action of light. Kober,[8] in a spectrographic study of amino-acids and polypeptides, and Harris and Hoyt,[9] in a study on the possible origin of the toxicity of ultraviolet light, have added some evidence to that already known, but much more is needed. All the ultraviolet work, up to a very recent date, was done with the iron core arc, tungsten core arc, and the old type quartz mercury vapor arc. The ultra-

violet ray apparatus is going through much the same evolution that the roentgen ray apparatus has gone through: from the static with a capacity of one or a very few milliampères through the tube to the modern high tension transformer and Coolidge tube outfit, capable of answering almost any demand made upon it.

The old carbon arc gave limited quantities of ultraviolet light of the longer wave lengths. The various improvements as different minerals were substituted in the composition of the carbon, resulted in greater quantities, but the wave-lengths remained comparatively long, and the constant attention demanded, the noise, heat, their unsteadiness and their many mechanical faults, kept them from being extensively used. With the advent of the quartz mercury vapor lamp with its spectrum reaching into the shorter wave-lengths, and nearly all the faults of the older arc lamps eliminated, a distinct move forward was made. A new type of quartz mercury burner has been on the market about a year. Spectrum tests just being finished at the University of Chicago would indicate that its spectrum goes to the limit of quartz transmission, or about 1850 Angström units. No intensity tests have been made, so far as we have been able to determine, but judging by its clinical effects it will probably be found to give a great volume of the shorter wave-length rays. With the new burner an erythema can be produced in about one-third of the time required by the older quartz mercury type. Air and water cooled lamps of old and new quartz mercury type are in constant use in our clinic, and both are efficient in increasing skin tolerance to the roentgen rays when used properly. By a series of experiments with the effects of ultraviolet light from an iron arc unscreened and filtered through various substances, such as clear glass, red glass, Wood's ultraviolet glass, picric acid, etc., upon the leucocyte count in rabbits, Clark[10] has shown that the shorter ultraviolet rays are the ones producing the leucocytosis, and that the longer ultraviolet wave lengths, in common with nearly all the longer light wave lengths, produce a fall in the leucocyte count. It would seem, therefore, that the use of the quartz mercury lamp, which gives much shorter wave lengths

than any of the arc lamps, would be preferable wherever a high leucocyte count or a marked dermatitis is to be desired. From a clinical standpoint, it is a matter of common knowledge among extensive users of the ultraviolet light that this physical remedy possesses remarkable value in a wide range of conditions. The rapidity with which certain morbid conditions can be modified is illustrated by Case V, which illustration could be duplicated in extenso from our case records, did space permit. It is a routine practice in our clinic to prescribe general ultraviolet radiations in all suboxidation states and all so-called toxemic conditions. Results from its use in metabolic disorders are usually prompt and vigorous. Its anodyne properties in such conditions as gastritis, gastric and duodenal ulcer and many malignancies have been, and still are, an unexplained mystery to us. Diabetes seems to be the only metabolic derangement where actinotherapy cannot be used. In any dosage whatever, it causes a diabetic to show, promptly, symptoms simulating surgical shock, or even anaphylaxis. The best explanation of this that we have seen is one given by McCaskey,[11] than whom, certainly, very few men in this country have had more experience in actinotherapy or have kept closer metabolic check upon their cases. Discussing diabetes he states:

"Let us for a moment discuss the constitutional disease, diabetes. Here, we have an endocrine breakdown. We now know that ultraviolet light affects the acetone components of metabolism by increasing or activating their decomposition to gas formation (Schanz, F., *Arch. f. d. ges. Physiol.* (Pflüger's) 1918, pp. 170, 646.) It has been my observation that in the application of quartz ultraviolet light to the human body, the individual's oxidation index is invariably raised to a higher percentage. For instance, a patient free from diabetes, whose urine reveals a proportion of urea nitrogen to total nitrogen of 50 per cent, will, after the application of several months' treatment with quartz ultraviolet light, have this proportion raised 20 to 30 per cent. Ordinarily there exists an idea that diabetes is a disease of suboxidation. This idea is a fallacy; it is not borne out by the chemical facts, for invariably the urine oxida-

tion index of this type of endocrine breakdown is above 85 per cent urea nitrogen to total nitrogen. My last two diabetic cases revealed a peak of 89 per cent and 88 per cent, respectively. As quartz ultraviolet light stimulates the oxidizing power of the synthetical forces of the body and as, in my judgment, diabetes is a superoxidation process, treatment with ultraviolet light cannot be administered at all, so long as the patient's metabolism is not in chemical equilibrium. During the past four years of my work with ultraviolet light in constitutional disorders, I have tried it repeatedly in diabetes, from small to moderate doses. Always the same result occurred, namely, the patient reacted poorly and gave every indication of increased toxic distress similar to anaphylactic shock. As a result of these detrimental toxic experiences, I, today, do not administer ultraviolet light to a diabetic.

"To summarize: A technic for the better coordination of the kinetic bodily forces may be divided into two parts, one relating to internal, the other to external technic.

"Internal technic involves the accurate quantitative knowledge of the constituent chemical ingredients of the blood and urine and a heart electrocardiogram. It further involves the regulation of the chemical food intake to the chemical outgo, so that a nitrogen equilibrium is maintained.

"The external technic involves the treatment of the body skin surface with quartz ultraviolet light, the absorption of which stimulates tissue metabolism. In toxic quantities quartz light produces anaphylactic shock. With the exception of diabetes, however, quartz light results in a raising of the factor of tissue vitality, or, it might be termed, of the patient's prophylactic resistance to disorders of nutrition, whether of acidosis or other low oxidation states."

So much for the ultraviolet constitutional effects. The conjoint use of the ultraviolet and the roentgen ray was suggested to me gradually by a comparative study of both their local and general effects, and by the ease with which a *beginning* roentgen ray dermatitis could be cut short and, clinically at least, cleared up by vigorous actinotherapy. And the ultraviolet

therapy in these cases, to be effective, must be vigorous. It is effective even after ulcer formation begins, provided it is used before masses of cicatricial tissues have formed. Once these have formed the case should not be expected to respond to actinotherapy alone. Surgery, radium, diathermia, or some other means of softening or eliminating the scar tissue must precede the application of the ultraviolet light. We have seen it stated that the use of the the actinic rays might be followed by xeroderma pigmentosum or skin cancer. We have never been able to authenticate a case of this kind from heavy actinic doses. No doubt there have been cases due to irritation from the actinic ray in the sunlight (which is of the longer wave length—never below 2910 Angström units, and of no great intensity as compared to quartz-burner intensity) but in this case we would state that clinical experiences lead us to believe that the skin may react to the actinic ray irritation somewhat as it acts when telangiectases form from roentgen ray, i.e., that it is more apt to form from small doses over considerable area, often repeated, than from heavier dosage. We have been cautioned by prominent roentgen ray therapists that it was against all the rules of the game to superimpose an actinic erythema upon a skin that had already received a dermatitis dose of roentgen rays. We can only answer by stating the clinical fact that we have been doing it for a number of years without a single depilation occurring, or symptoms which would indicate that a dermatitis had occurred, and have greatly exceeded dosages which, before the use of this method, regularly gave us a dermatitis. These well-meant cautions have had the effect of causing us to treat a few hopeless cases first and wait for months before increasing the dosage proved safe in those cases. The result is that we have pushed the dosage only to the figures given in the appended cases. Whether these dosages can be much extended is a problem for future research. We have, until now, been handicapped by the fact that our laboratory has been running overtime on routine work and could not take on any research work for us along this line; but preparations are being made for expansion, and facilities planned for the doing of a

great number of experiments by which we hope to prove on a large scale the value of this combined technic, and set out the limits of safety.

The x-ray outfit used in these cases was a Wappler, King model, Coolidge tube, medium focus; and the constant factors were: Spark gap, 9 in., (except splenic area, Case II, where it was 10 in.); target skin distance, 8 in.; filter 6 mm. aluminum, 2 mm. leather; ma. in tube, 5; time variable, as given. The ultraviolet outfits were of the quartz mercury vapor type both air cooled and water cooled. The roentgen ray treatments were given by the medical officer roentgenologist and 2 competent x-ray technicians, and every factor checked up by each of us. The timing was done by an interval timer checked by three standard watches set in synchronism. The spark gap was always at least that given, and broke over several times, with the parallel gap set at 10 and 11 in. respectively. A series of 27 skin areas tested on control subjects of approximately the same ages and complexions as the cases cited (areas were on back between shoulder blades) gave the time necessary to produce a first degree erythema with the 9 in. gap, and other factors used as an average of 17½ ma.min.

As the ultraviolet technic was the same in all cases, the detailed dosage will be given only in the first case. The essence of the technic is to prepare the skin area to be treated by the roentgen rays by a series of actinic-ray erythemas produced as rapidly as the preceding one begins to die out, and repeated until heavy tanning takes place, or, in case the subject will not tan, for approximately four weeks; and at the same time give general ultraviolet radiations (not necessarily so severe, but as strong as comfort of patient will allow) for the constitutional effect. When it is decided that the area is prepared sufficiently, allow the last actinic erythema to fade out, and then give the roentgen ray treatment. On the same day, but *after* the roentgen ray treatment, give at least as much ultraviolet exposure as was given at the last previous ultraviolet treatment over the area treated by the roentgen rays. Also keep up the general ultraviolet exposures. Repeat the application of the ultraviolet in the same

or slightly increased dosage over the roentgen-treated area about every forty-eight or seventy-two hours, as the actinic reaction indicates, until that area has had at least 3 good actinic exposures, and then allow all actinic erythema to die out, so as to be able to detect the roentgen erythema which will come up later if it is to appear. In practice we cover a small central area after 2 or 3 actinic treatments, and keep up the ultraviolet applications to all the rest of the area for a period of three weeks, using the small covered area as a control for the x-ray erythema.

CASE I.—Male, aged thirty-seven, American, Sergeant, U. S. Army.

Family History.—Negative.

Personal History.—Negative.

The first appearance of a tumor size of a hickory nut on left forearm in October, 1918. This was removed in March, 1919, at Fort Riley, Kansas.

Patient was sent to Camp Upton in December, 1919. Diagnosis, recurrent tumor, left forearm. This was removed December 17, 1919, being the second operation. A specimen was sent to the laboratory for pathological report.

Diagnosis.—Sarcoma, mixed cell type. Tumor recurred rapidly after second operation.

Patient admitted to Army General Hospital April 27, 1920. Tumor size of cocoanut on the ulnar aspect of left forearm.

X-Ray Report (April 27, 1920).—Stereo of left forearm, upper third including elbow shows growth of soft tissue not involving the bone. From the lateral plates the upper third of radius is bowed forward as if from pressure in this region. There is a slight amount of thickening of the periosteum of the ulna in this region. The cortex of both bones is intact, the elbow is negative, as are the plates of the chest.

May 11, 1920.—Specimen from epitrochlear gland to laboratory.

Gross Examination.—Small mass 1 cm. long by ¾ cm. thick.

Microscopical Examination.—Small amount lymphoid elements, being a small lymphoid follicle at one edge of section. Main structure of section is a loose mass of cells, large spindle cells predominating, with numerous large round cells. Also connective tissue and newly formed blood-vessels. No giant cells.

Diagnosis.—Sarcoma, mixed cell, large spindle cells predominant; not a lymph gland.

May 29, 1920. X-ray of chest. Stereo of chest shows slight retraction on lower right lateral aspect of chest wall. Heart and chest otherwise negative except for four circular areas of consolidation which give the typical snowball appearance of metastasis of sarcoma.

Three areas appeared after the last plate was made and one, which was present in the last plate, was not more than a third of its present size and had not taken on any characteristic appearance at that time. It was located

in the lower part of the hilum where small areas of consolidation are often found. No special significance could have been given it then. Small accumulation of fluid at the base of left chest which was not present at the previous examination.

Diagnosis.—Sarcoma of left forearm with metastases of chest. Patient

Fig. 47.—Case I, showing case the day before amputation was performed, and location of metastases.

referred to physiotherapy service May 27, 1920, at which time preliminary treatment was started and the photograph which accompanies this article was taken.

Operation Report.—(May 29, 1920.) Sarcoma left forearm with axillary and pleural involvement by metastasis.

Operation.—Amputation middle third humerus; dissection of axilla. Curved incision 12 inches long from middle of pectoralis major along course of cephalic veins to lower third of upper arm. Tendon of pectoralis major divided ¾ inches from its insertion and turned back. Axilla dissected, removing all fat and glands. Axillary vein dissected clear, exposing brachial plexus. Flap dissected on upper arm (rachet) and brachial artery and vein, cephalic and basilic veins tied. All nerves injected with alcohol and cut by fishtailing after pulling down. Muscles cut through and bone sawed, periosteum removed off cut edge, triceps sewed to biceps over bone end by interrupted sutures, wound closed.—Major Jones.

PHYSIOTHERAPY TREATMENT

NOTE. In giving the ultraviolet exposures, to save space, the air cooled ultraviolet lamp will be designated by "A" and the water cooled ultraviolet lamp by "W." The time in minutes will be the first numeral, X will mean "at," and the following numeral will be the number of inches from target to skin, or in the case of contact exposures with the water cooled lamp the letter "C" will denote contact; thus 2 × 18-A will mean two minutes at 18 inches with the air cooled lamp and 10 × C-W will mean ten minutes at contact with the water cooled lamp, etc.

Date	*Region Irradiated*	*Exposure*	*Ultraviolet Skin Reaction*
May 27	Over metastases	6 × 1-W	Mild erythema
May 28	Over all sides chest	2 × 22	Mild erythema
	Operation		
June 15	Over metastases	6 × 1-W	Mild erythema
June 15	General over chest	2 × 22-A	Mild erythema
June 18	General over chest	2 × 22-A	Mild erythema
June 20	Legs, front and rear	2 × 22-A	Mild erythema
June 21	Over all chest	3 × 22-A	Mild erythema
June 21	Over metastases	4 × 1-W	Mild erythema
June 22	Legs, front, rear	4 × 22-A	Mild erythema
June 23	Over chest	4 × 22-A	Mild erythema
June 24	Over metastases	9 × 1-W	Good reaction
June 25	Chest, legs, all sides	3 × 22-A	Mild reaction
June 26	Legs	5 × 20-A	Good reaction
June 26	Chest	4 × 20-A	Good reaction
June 27	To metastatic areas	10 × C-W	Heavy reactions
June 28	Chest	8 × 20-A	Good reaction
June 28	Legs	4 × 20-A	Good reaction
June 29	Chest	7 × 20-A	Good reaction (tanning well)
June 29	Legs	9 × 20-A	Good reaction
June 30	Chest	10 × 20-A	Mild reaction
June 30	Legs	8 × 18-A	Mild reaction
July 1	Legs	8 × 18-A	Mild reaction

Date	*Region Irradiated*	*Exposure*	*Ultraviolet Skin Reaction*
July 1	Chest	10 × 18-A	Mild reaction
July 2	Chest	12 × 18-A	Mild reaction
July 2	Metastases	10 × —C-W	Mild reaction
July 5	Metastases	10 × —C-W	Mild reaction
July 5	Chest	8 × 15-A	Mild reaction
July 6	Chest	10 × —15-A	Very slight reaction (Acct. deep tan)
July 6	Legs	8 × 18-A	Very slight reaction (Acct. deep tan)
July 7	Metastases	11 × C-W	Good reaction
July 8	Chest, legs	10 × 18-A	Mild reaction
July 10	Chest	12 × 18-A	Mild reaction
July 10	Metastases	12 × — C-W	Mild reaction
July 12	Chest	12 × —18-A	Good reaction
July 12	Legs	10 × 18-A	Good reaction
July 13	Chest	12 × 18-A	Mild reaction
July 13	Legs	10 × 18-A	Mild reaction
July 15	Metastases	15 × 1-W	No reaction
July 18	Chest	15 × 18-A	None
July 19	Chest	15 × 18-A	None
July 20	Chest	15 × —16-A	None
July 20	Legs	15 × 16-A	None

Area of experiment 6 × 4½ inches on antero lateral aspect of lower right chest, over the largest double metastasis. Diagrammatic reproduction of area follows.

<table>
<tr><td>1</td><td>A</td><td>4</td><td>D</td></tr>
<tr><td colspan="2">July 30
X-ray dosage 45 ma.m. to areas 1 and A</td><td colspan="2">August 2
X-ray dos. 25 ma.m to areas 4 and D</td></tr>
<tr><td>10 × C-W July 30
10 × 20-A July 31
10 × 1-W Aug. 2
Etc.
See below</td><td>No after treatment with ultraviolet</td><td>Ultraviolet same as square Number 1</td><td>No after treatment with ultraviolet</td></tr>
<tr><td>2</td><td>B</td><td>5</td><td>E</td></tr>
<tr><td colspan="2">July 30
X-ray dosage 62½ ma.m. to areas 2 and B</td><td colspan="2">August 4
X-ray dos. 75 ma.m. to areas 5 and E</td></tr>
<tr><td>Ultraviolet same as square Number 1</td><td>No after treatment with ultraviolet</td><td>Ultraviolet same as square Number 1</td><td>No after treatment with ultraviolet</td></tr>
<tr><td>3</td><td>C</td><td>6</td><td>F</td></tr>
<tr><td colspan="2">August 2
X-ray dosage 50 ma.m. to areas 3 and C</td><td colspan="2">August 4
X-ray dos. 75 ma.m. to areas 6 and F</td></tr>
<tr><td>Ultraviolet same as square Number 1</td><td>No after treatment with ultra violet</td><td>Ultraviolet same as square Number 1</td><td>No after treatment with ultraviolet</td></tr>
</table>

The lettered areas were not treated with ultraviolet *after* the x-ray exposures were made. The numbered areas were treated with ultraviolet as follows:

On the day of x-ray exposures and immediately after the x-ray had been given:

Same day	10 × C-W
Next day	10 × 20-A
Third day	10 × 1-W
Sixth day	15 × 1-W
Ninth day	15 × 1-W
Tenth day	12 × 16-A

In an ordinary case with a moderate overdose of x-rays, the subsequent ultraviolet treatments would be stopped at the end of six or seven days, as the x-ray erythema usually comes up in from eight to fifteen days. In this particular case, we carried the ultraviolet treatment to ten days, and used the lettered areas as a control to watch for the x-ray erythema. We fully expected to produce an erythema on the lettered areas, and were trying hard to prevent it on the numbered areas. We were pleasantly surprised when no erythema resulted upon either the lettered or numbered areas. In addition to the radiation directly through the metastases, the two larger ones were treated by crossfiring, from four angles, using a 50 ma.m. exposure. A marked x-ray dermatitis appeared in the axilla, the hair coming out and ulceration starting on the skin of the stump where we had neglected to tan the skin of both areas, on account of the dressings on the stump. This was not from direct exposure of these areas to the x-rays, but was caused by the crossfire rays emerging from the body at this point. It quickly cleared up under a few ultraviolet treatments. In addition to the x-ray experiment upon areas F and 6, and to test the irritability of the skin after these massive dosages, a capsicum plaster was applied. When no result was evident in twenty-four hours, a second, and later a third plaster was applied to these same areas before a mild blister resulted. A control gave a blister overnight.

Location of metastases had been marked on the chest wall on the photograph. Under this treatment the metastases rapidly dropped out of the picture. Patient's general condition im-

proved from the start. He was transferred to a hospital nearer his home a short time after his course of treatment was finished, but continued to improve. He visited our clinic last month (May, 1922). He has regained his normal weight and says he has, and looks to have, rugged health. He is developing a hard mass in his left calf which is probably sarcomatous in character, and has a small suspicious area in the lower posterior chest, which is not one of the original metastases. This area was not in the heavily rayed portion of the chest. He has been advised to return at once for a full course of treatment, and is taking the necessary steps to be admitted as a patient to this hospital. We hope to control these metastases as the others were controlled.

CASE II.—Male, aged twenty-nine, American, chauffeur.

Family History.—Negative. No cancer, tuberculosis or insanity in family.

Personal History.—Negative. Habits good. Smokes cigarettes.

Drafted May 18, 1918. Discharged March 15, 1919. First noticed sore on lower lip, left side, December 10, 1918, in Beautesart, France. Wassermann done at this time negative. Sore started as small pimple, ointments applied. Healed and broke open at intervals until his discharge, gradually growing larger. Discharged at Camp Dix and immediately consulted his family physician. Wassermann again negative. May 20, 1920, excision of growth was done. Remained in hospital one week and returned home. Three weeks later gland in neck removed. Wound broke down after five months, and after consulting his physician again, he was treated until February, 1920, when he was referred to another hospital, where he received 2 applications of radium, three weeks apart. Relief for some months and then pain and swelling started again. Admitted to this hospital December, 1920. Condition as shown on April 2, 1921, when he was referred to our clinic for treatment. Ultraviolet treatment in preparation for roentgen ray treatment started, although results were very problematical, due to degree, age and previous operations. At end of ten days urgent pressure symptoms developed with a rapidity which made it inadvisable to defer roentgen ray treatment, and after consultation with several surgeons it was decided to give him the maximum dose although he had not had the areas properly prepared. On April 11th, he received 75 ma.m. over metastatic tumor in left occipital triangle; on April 12th, 75 ma.m. over primary growth area and over metastases in left superior carotid triangle; on April 13th, 75 ma.m., over metastases in right occipital and right superior carotid triangles; and on April 14th, 75 ma.m., over metastases in region of left parotid gland. On May 2nd, he received 75 ma.m., over left parotid region again; on May 9th, 75 ma.m., over right submaxillary triangle. In spite of these dosages with their crossfire rays emerging in some cases in another treated area, and his insufficient

preliminary ultraviolet preparation, no dermatitis resulted. On June 11th, 13th and 15th, he again received 75 ma.m., over the left parotid, right submaxillary and primary areas respectively. His ultraviolet was kept up regularly. He is still alive, but failing, and his latter treatments were more to

Fig. 48.—Case II. Epithelioma, with general involvement of adjacent glands.

satisfy him than in hope of doing any real good. His beard is still in place and pains him when it is pulled. Blood count ranges from 6,624,000 reds to 4,080,000 and whites 6,600 to 7,200. Hemoglobin 65 to 73 per cent, differential small mononuclears 16 and 17 per cent, large mononuclears 3 and 4 per cent, eosinophiles 1 and 2 per cent, neutrophiles 77 per cent.

CASE III.—Male, aged thirty-four, Italian.

Diagnosis.—Osteosarcoma with metastases.

Family History.—Negative.

Personal History.—Negative. Smokes cigarettes.

Fig. 49.—Case III, (*a*). Showing primary tumor on right clavicle and metastatic areas. Also showing absence of dermatitis after a 90 ma. min. roentgen-ray dose with a 10 in. gap.

May, 1920, had pains more or less generalized over body, but especially over right clavicle. In July, 1920, noticed lump over right clavicle. Treated at home until October, 1920, when he was admitted to a hospital in New York City, remaining there until February 3, 1921, when he was admitted to this

hospital. Condition on being admitted: Cast from 7th cervical to junction between middle and lower third of the tibia. Report of consulting orthopedist (February 4, 1921):

"There is a large, spherical mass attached to right clavicle. Condition is probably a sarcoma with metastases in spine and chest. Liver also enlarged, edge being felt about 12 cm. below costal margin. Condition in-

Fig. 50.—Case III, (*b*). Showing metastatic areas in spine and exfoliation following overdose of actinic ray.

operable. Request that x-ray and summary of history from the New York hospital be obtained."

In December, 1920, patient also had pleurisy with effusion while in the New York hospital. Patient was sallow, anemic, emaciated, and could not be removed from his cast, which shell extended from neck to heel and partly up the sides of the body. Careful lifting and turning were required to get him out of his cast for treatments, and at first this caused him great pain.

On April 11, 1921, was given preliminary ultraviolet treatment, and then 75 ma. min. over each of the two most painful areas on spine. On April 12th, the primary growth at sternal end of right clavicle received the same dose; on April 13th, the metastases in region of sternal end of left clavicle received 75 ma. min., and on April 14th a cluster of metastases at costal extremities of 6th, 7th, 8th and 9th ribs received 75 ma. min. The roentgen-ray plates showed all these metastases except that clear plates of the spinal lesions were impossible to obtain. Pain began to lessen in all areas thirty-six to forty-eight hours after the roentgen-ray treatment was given. On April 28th, after patient had complained of constantly increasing pain in splenic area, and a hard mass could be made out by palpation, he was given 90 ma. min. with a 10 in. back-up spark over this area. The pain lessened at once, but persisted for some two weeks, when it also disappeared. No roentgen ray sickness resulted from this dose, and Fig. 49 shows the condition of the hair over this area, showing that on the sixteenth day after the x-ray dose, when this plate was taken, the skin of the abdomen could be pulled out an inch or more by tension on a dozen hairs. This test was made daily for six weeks after the administration of the x-ray dose, and showed a healthy condition of the hair follicles all the way through. Fig. 50 of the same case shows what happened when he was given the usual time and distance in one of his preliminary actinic ray treatments, but when a brand new burner had been substituted, and the attendant overlooked the notice on the lamp ordering exposures cut in two until the new burner could be standardized. The whole exposed area exfoliated in large strips, and small blisters were produced in the center where the intensity was greatest. In spite of his poor condition (his blood picture showed a condition almost exactly simulating pernicious anemia) he became so much better after the x-rays were administered that he was able to get out of his cast into a wheel chair by his own efforts and propel himself around the ward. His anemia is gradually taking him down again, and it is only a question of time for him, in spite of transfusions or other expedients. The primary growth has retrogressed one-third in size, and the nodules on the ribs have practically disappeared. He is too ill to move to the roentgen-ray department for further plates.

Case IV. Male, aged fifty-seven, Irish, merchant marine.

Diagnosis.—Basal cell epithelioma.

Family History.—Negative.

Two and one-half years ago a small sore appeared. Treated with various ointments, healed, but broke open again. Says there was no mole in that locality. Sore gradually grew larger until it reached the size and appearance shown. This case is shown only because of his complexion, his skin being of the type that blisters readily, but will not tan under the strongest ultraviolet-light exposures. After preliminary erythemas from actinic rays, under which the lesion almost disappeared, he was given 75 ma.min., and parotid and carotid regions are now being prepared for prophylactic raying,

on the remote possibility that a metastasis might appear later. He was given the x-ray treatment on May 31st, and up to June 25th had shown no signs of erythema.

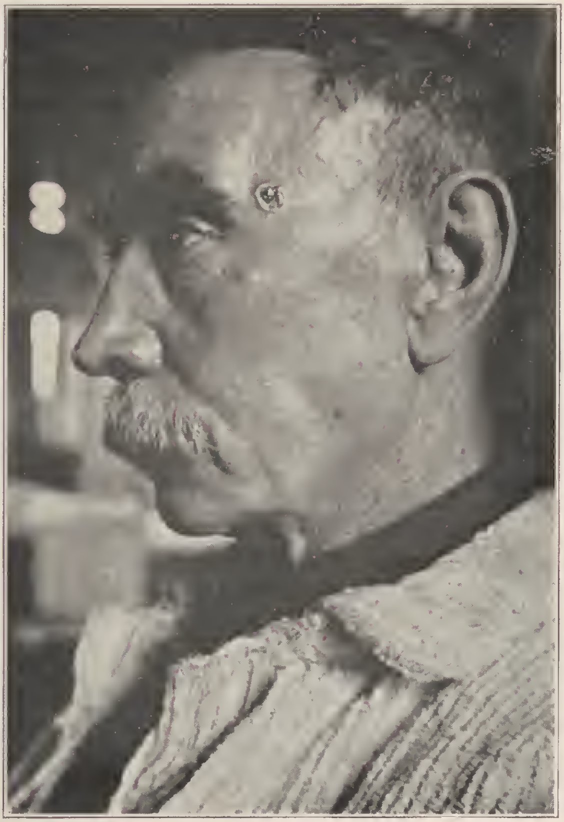

Fig. 51.—Case IV. Showing type of basal cell epithelioma, clear skin, freckled, which would not tan under actinic ray.

Case V. Male, aged twenty-nine, American.

Diagnosis.—General paronychia.

Family History.—Negative.

Personal History.—Negative, except that patient was gassed in 1918. A short time afterwards he developed the pustular condition of the nails which progressed in spite of all treatment. When he came to our clinic a year ago he had lost, or had had removed, every finger and toe nail, and pus was exuding from the matrix. The x-ray plate showed periostitis of every terminal phalanx. He had been given vaccines, both stock and autogenous, had had applications of iodoform and glycerine for months, etc., and was finally

referred to us for treatment. Every one of our air-cooled actinic-ray lamps was running overtime on serious cases, but after a few days a place was found for him on one of the water-cooled lamps, and he was started on *local* ultraviolet treatments. He made no improvement until a vacancy occurred on one of the air-cooled lamps (ultraviolet) when he was given *general* treatments in addition to the local ones. Improvement was manifest by the fifth day, and in seven and a half weeks he was discharged from the army and went home. He kept in touch with us by writing at intervals, and after a lapse of eight months he wrote that his hands and feet were perfectly well, and that he had new nails coming in on all fingers and toes; but he wanted to know why they were so brittle. This case had received no treatment for months before he came to our clinic, and received no other treatment at the hospital at any time except the actinotherapy outlined. An x-ray plate taken the day before he left showed no signs of a periostitis.

Fig. 52.—Case V. General paronychia.

SUMMARY

In the human organism the epidermis is the natural covering which acts as a defense against certain stimuli in which the individual is immersed. Individuals have constantly been exposed to the sun's actinism, so that, *a priori,* the skin is the naturally provided filter against such actinic effects as must be excluded from the body, but it is at the same time permeable to those actinic effects which act as adjuvants in fostering the physiological unity of the individual.

The tanning or sun-burning of the skin may be accomplished

more rapidly and under more perfect control in the clinical theater by the use of scientifically elaborated apparatus, whose function it is to duplicate with intensity the therapeutically useful actinic spectrum.

The trial and error of empiricism has established that an effect of clinically induced "ultra sun-burn" is such as to provide an epidermal pigmentosis. This newly induced epidermal pigmentosis so reacts that the area involved, when exposed to relatively soft x-rays, permits of the assimilation by that part of a greater quantity of physiologic roentgen radiation, at the same time precluding the physiologically detrimental effect that would otherwise be produced on an area of skin unexposed to intense actinism.

An extremely important principle is discovered; the principle that nature has provided the guide for offering a protective mechanism whereby spectral phenomena closely allied to ultraviolet activity, or x-rays, can exert very helpful and stimulating influences without exercising deleterious effects such as are produced without proper preparation.

The application of this fundamentally important principle is at once obvious. It precludes the necessity for elaborating expensive and impractical apparatus to generate an unnatural radiation in the treatment of disease. For with the unnatural x-ray radiation, unnatural filters of copper, aluminum and zinc are made necessary. In effect, ultraviolet treatment of an area provides the natural means that the laboratory experimenter endeavors to secure through the use of copper and other unusual metallic elements.

The essential feature of this clinical research is to point out that ultraviolet and x-ray radiations are physiological complements. The one may be used in symbiosis with the other. That is, the ultraviolet applied first renders the area more resistant to the subsequent radiation with the roentgen rays. The roentgen rays applied first may produce a dermatological change injurious to the organism; but the effects of that injury can be alleviated or entirely neutralized by applying secondarily the ultraviolet radiation. From this foundation it is adduced that

the ultraviolet greatly extends the previous limits of x-ray efficacy in the treatment of disease.

Hence the conclusion of an empirical research is obviously the empirical restatement of the research itself and carries with it the single conviction that the clinical trial of the method presented accomplishes more than speculative conjecture based on hypothetical presumptions.

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CHAPTER XIII

TREATMENT OF X-RAY "BURN"

ACUTE BURNS

The treatment of acute and chronic x-ray burn here given is based upon original researches extending over a period of many years. The stock allegation of the damage suit lawyer is that an x-ray burn, once inflicted, is progressive, incurable and fatal to limb, life or both. This is no longer true.

To avoid confusion we shall call those burns characterized by extensive open ulceration or slough with well defined irregular borders shading off to apparent normal skin through an erythematous zone of varying width "acute" burns even though they have appeared many months after the exposure. We will name the more diffuse areas characterized by extensive skin atrophy, discrete ulcers, keratoses, etc., where the tissues have not broken down *en masse* "chronic" burns. This division is necessary because of the difference in the treatment.

The treatment of acute burns is easy and results are secured rapidly. It is not unusual to see acute burns having a diameter of from six to fourteen inches and a depth varying from a fraction of an inch near the circumference to as much as an inch and a half or more in the center fill in and heal over in from four to twenty-four weeks under the treatment below outlined. Often the intense pain will ease up after the first treatment and entirely disappear in five or six days. The healing is unbelievably rapid where proper appliances and technic are used. However, a healed x-ray burn is not necessarily a cured x-ray burn and treatment should not be stopped the moment all symptoms have abated and the ulcer has healed over. Much more treatment is necessary before the more diffuse and deeper fibrosis can be removed and unless this deeper damage is counteracted it may progress slowly to a point where tissue breakdown will again occur.

Fig. 53.

Figs. 53 and 54.—Two photographs of the terminal healing stages of a bad x-ray burn of the hand. These two pictures were taken Dec. 11 and Dec. 22, 1921, respectively, and show the rapid progress made under treatment. In the first the tendon of the ring finger is still partly exposed and the second shows it covered over and the whole area smoothing down. Unfortunately the negatives showing the original condition and a week later were destroyed before we could secure prints. A glass rod could be placed under the tendons of the back of the hand and rolled for two inches or more. This man is well known in the x-ray game. Dr. Albert F. Tyler of Omaha completed the terminal stages of the treatment and the hand now has remained healed for over a year. The pain was completely relieved after four treatments and subsequent healing was very rapid.

In acute burns the maximum damage is on the proximal surface and as heat is the first remedy in the attack the deep therapy lamp (1500 watt bulb lamp) is at first used, as under its appli-

Fig. 54.—(For description, see Fig. 53.)

cation the point of maximum heat is the proximal surface whereas under diathermia the point of maximum heat is somewhere in the tissues between the electrodes, and the raw, painful sur-

faces would not permit of proper application of diathermia electrodes anyway for direct treatment to ulcers. So the treatment is started out with the application of the heat from a deep therapy lamp over the ulcerating surface and for several inches all around on the skin. The heat is applied for at least thirty minutes at first and the target-skin distance regulated to the patient's tolerance, making it as hot as can be borne without acute discomfort.

As soon as this application is finished the ultraviolet is applied. The ultraviolet treatment for the open ulcer and that for the surrounding skin is different. In the open ulcer it is absolutely necessary to stir up the greatest possible reaction to the ultraviolet light for the first treatment or two. The more intense this reaction is the faster will subsequent healing take place. To produce this intense reaction a double or triple fourth degree erythema dose should be administered at one session, and in a day or two, if the reaction does not show proper intensity, repeat with an even larger dose. If there are flaps, stumps of muscles, decaying fascia, or sulci leading up under the tissues the proper exposure will have to be provided for by everting flaps, exposing the floor and under side of stumps as well as the upper surface, clipping out all projecting fascia and cleaning off all sloughs or dead tissue as the ultraviolet will not penetrate these obstructions. If they are not removed or lifted to one side the areas under them will not receive the necessary ultraviolet light. It is well to put on a quartz rod pyorrhea applicator and make exposures into all pockets the first treatment or two if any such pockets are present. At subsequent treatments this is not necessary. Either the air-cooled or the water-cooled lamp may be used for these first treatments but afterwards the air-cooled lamp is more convenient as the burner on the air-cooled is much larger and the whole area can be treated at one exposure whereas the area, if of any extent, must be subdivided and each subdivision given a separate exposure if the water-cooled lamp with its very much smaller active field (when used at a distance) is used. In either case, the shorter the exposure necessary to blister the skin, say of a forearm, at a

Fig. 55.—Figs. 55, 56, and 57 show the progress of an acute x-ray burn under the ultraviolet heat treatment outlined in this chapter. Brief history: Overexposure in April, 1922. Vesiculation appeared in three weeks. Ulcerated and healed after three months. In October the ulcer again appeared (size of hand) and became larger and deeper. Edges of ulcer irregular and progressing into the indurated edges. Zone of induration and erythema extending on all sides of ulcer for more than two inches. Pain excruciating. Fig. 55 was taken at a distance from the camera to show relative size. Figs. 56 and 57 were taken at a much closer range. Fig. 55 shows condition after three weeks of heat-ultraviolet applications. Note reparative granulations and also a sloughing muscle and fascia in floor of ulcer. The case was referred to Dr. R. W. Fouts who in turn consulted with the author through mutual friends. I did not see the case until the doctor had it well on toward recovery.

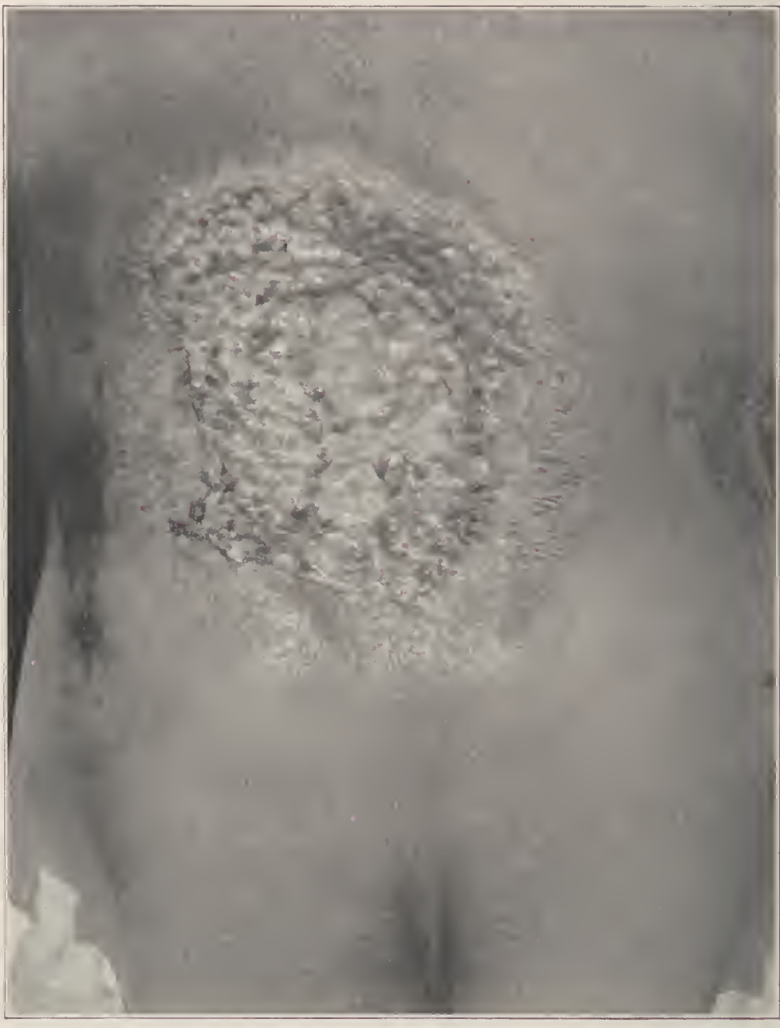

Fig. 56.—Condition four (4) weeks after that shown in Fig. 55. Repair progressing rapidly except over the sloughing fascia which later had to be removed. The pain lessened markedly after the first treatment and almost disappeared in a week, patient being able to sleep well after first two or three treatments.

given distance, the better the lamp for these first treatments.

A water-cooled lamp that will not blister in much less than a minute with the quartz window in contact with the skin (untanned skin) or an air-cooled lamp that will not blister in two

Fig. 57.—Condition five weeks after that shown in Fig. 56. The sloughing fascia and muscle has been removed clear to the edge of the overexposed area. Rest of ulcer rapidly healing. Ulcer now (five weeks after that shown in Fig. 57) is healing rapidly and is practically covered over. The rapid healing, disappearance of pain and loss of foul odor in these cases is remarkable. This case illustrates the value of the method better than cases treated by myself. Photos reproduced by courtesy of Dr. Fouts.

minutes at ten inches burner-skin distance, is not nearly so satisfactory for this work as one that will blister in these exposure times or less.

After the first one or two heavy reactions have been produced and when reparative granulations begin to appear then reduce the amount of ultraviolet exposure by increasing the target-skin distance and decreasing the time. Care should be taken at this stage never to make the exposures either of radiant light and heat or the ultraviolet strong enough to destroy the granulations. Give stimulant but not destructive doses of ultraviolet to the ulcerating surface from this time on.

If granulations spring up on only part of the area and not upon other parts then cover the granulating areas with oil silk and black paper cut to shape to protect the granulations from the heavy ultraviolet exposure and repeat the first heavy exposure over the *nongranulating area.*

As the shorter the wave length of ultraviolet the more active it is in producing a reaction and as the most active ones are filtered out by air, it is evident that at the first treatments the water-cooled lamp would be used with the quartz window in contact with the ulcerating surface and if the air-cooled lamp is used with the burner as near to the ulcer as safety will allow. As the exposure time will be very short (30 seconds at 5 inches is more than twice as heavy an exposure as 60 seconds at 10 inches) and as the quality of the ray delivered (reaching the surface) at five inches is much better for our present purpose than would be the case were the exposure made at 10 inches and as the heat of the burner—intense as it is—is not sufficient to produce a slough in this short exposure time, the exposure may be made at a five inch target-skin distance. After the first treatment or two the water cooled burner is moved back to three inches and the next treatment to six inches, later to twelve inches thus cutting down the intensity of the exposures and changing the quality of ray being used. After the first treatment or two if an air-cooled lamp is being used the distance may be increased to from twelve to twenty inches—the faster granulations appear the farther away the lamp in succeeding treatments—until, by the time granulations are beginning to be well established, only the stimulation from the far ultraviolet rays (of course the longer wave length, sedative near ultraviolet rays

will be coming through too but the more stimulating effect of the far ultraviolet will predominate) is being used and, as soon as repair has frankly set in the lamp is moved back again to thirty inches or so where the sedative effects of the longer near ultraviolet will predominate and, from this time on all treatments will be given from the longer distances and given daily, care being taken not to overdo the ultraviolet.

The treatment of the erythematous skin area around the ulcer differs from that accorded the ulcer surface. Here the purpose is to produce *repeated* third degree actinic erythemas. As fast as the previously produced third degree erythema fades out another third degree erythema is again produced over the whole area. It will be found that increasingly large dosages of the ultraviolet will become necessary as each succeeding erythema is produced—the time of exposure will have to be increased as well as the target-skin distance shortened. It is not advisable to cut the target-skin distances for the long exposures down to less than seven inches or so as there is danger of a heat burn if long exposures at a closer target-skin distance are used. While these erythema dosages of ultraviolet are being administered to the skin, of course, the *ulcer surface* is to be protected by a layer of oil silk and black paper. Thus it will be seen that the successive ultraviolet exposures on the surface of the ulcer grow weaker and weaker, while those to the surrounding skin grow stronger and stronger.

These procedures properly carried out will heal almost any acute burn, but are not sufficient, alone, to remove the deeper damage. Resort must be had to conversive heat (diathermia) and ionizing dosages of x-ray. Massage and manipulation are added as soon as the healing of the ulcer makes it safe to use these measures but even then caution is used to do no trauma to the ulcer area proper, but to stir up the deeper structures underlying.

Diathermia can be administered through the tissues underlying the ulcer from electrodes so placed at some point around the curvature of the body that the path of heat traverses the tissues underneath the ulcer. Diathermia can be given with

benefit from the start of the treatment when it will not only help clear up the deep damage but, by so doing, increase the circulation to the ulcer area and hasten resolution there. The sedative diathermia technic is used.

An ionizing dose of x-ray (5 ma. min. from a 5 inch back-up spark tube, through one mm. of aluminum at an 8 inch target-skin distance) should be sprayed through the affected area once a week.

We have had the opportunity of treating only three cases of acute radium burns but these three cleared up under the ultraviolet even faster than acute x-ray burns. We see no good reason why the method of prevention or cure of x-ray burns should not be just as efficient in radium therapy as in roentgen therapy.

CHRONIC X-RAY BURNS

The treatment of chronic x-ray burn is very much more difficult than that of the acute variety and results are secured very much slower and at the expenditure of much more time and effort. It is a striking fact that most of the very worst chronic burns we have examined in consultation or have treated in our various clinics have either been produced directly from a static x-ray tube or have appeared upon men who had used the static x-ray for some years and then switched over to transformer outfits with their very much higher milliamperage outputs. Chronic burns giving a static origin history are almost without exception very much harder to clear up or check than transformer burns for the reason that they are much older, the damage in the tissues has appeared slower and there seems to be some difference in the ray from a static tube as compared to that from a transformer tube. Whether this is a qualitative or a quantitative difference is not yet entirely clear, but that—dose for dose—the difference does exist most of the more experienced therapists who have used and studied the clinical effects of the x-ray from both sources will admit. Most of us who received chronic burns from the static tube can return thanks joyfully for the fact that we are still alive because we were unable to do what we were

all trying to do—increase the milliamperage through the tube—until after we had learned more of the terrible danger and the steps necessary to avoid it. We shudder to think of what certainly would have happened had the modern high efficiency transformer outfit been handed to all of us some fifteen or twenty years ago. We did fairly well as it was.

Miraculous, almost, as are the effects of ultraviolet upon acute burns, ultraviolet alone will do little or no good in these chronic burns. It is a remedy for use *after* many other things have been done. Reactions from exposure to utraviolet light can only be produced provided the actinic ray can be delivered into the tissues and further provided the tissues are capable of reacting even if the ray reaches them. The skin over most of these chronic x-ray burn areas resembles nothing so much as the appearance of a piece of the skin head of a bass drum which has been soaked for a week in brine, sprinkled with a corrosive acid and then thrown out in the hottest sun to dry up in hard wrinkles, and this dead skin after such treatment, has just about as much permeability and reactivity to ultraviolet as has the atrophic, dry, keratotic skin of chronic x-ray burn. What, then, shall we say of any one who admits that he knows all about ultraviolet who attempts to clear up some of these worst cases of chronic burn by shining the actinic ray upon them for a few minutes a day and then cites the failure as a discredit to the method? Such deceptive statistics is one of the reasons that we have refused to go into a battle of case histories.

The first thing to be done in these cases where the damage is resulting from a slowly progressing interference with nutrition is to attempt to improve the nutrition. It is fortunate that the remedy most efficient for purposes of improving local nutrition—conversive heat—is also the remedy that is most efficient in resolving chronic fibrositic processes. Here, as in all other cases, where irreparable damage has already been done, it is too late to prevent it. If the checking and removing of the crippling pathology starts too late then failure is inevitable. The remedies should not be blamed for these failures.

The hands are most often involved so we shall outline a treat-

ment for chronic burn of the hands. At first our attention is devoted solely to producing repeated arterial hyperemias. This is done with the double cuff method of applying diathermia. These cuffs are applied one to each forearm and the cords from a d'Arsonval circuit attached one to each cuff. The circuit is finished through salt solution by placing the ends of the fingers of both hands in a half inch or slightly more of salt water in a

Fig. 58.—Type of beginning chronic x-ray burn of hands and feet which cleared up very rapidly under the heat-ultraviolet method. The feet cleared up after a single third degree actinic exposure but the hands required several treatments. Both hands and feet were given many subsequent treatments to insure complete removal of process and prevent recurrence.

single fiber or enamel pan or by placing each hand in a separate heavy china or glass dish each with a half inch or so of salt water in it and connecting the salt water in the two dishes together by means of a piece of flexible braided copper wire or simply by laying a strip of black tin or crookes metal into the water in one dish and then across into the water of the other

dish. This latter method obviates the rather tiresome position in which the arms and forearms must be held when a single vessel of salt solution is used as, in this case, the forearm of one side must be held so that a straight line passing down its long axis will cross the short space of salt water between the two sets of fingers and travel up the other forearm of the other hand. By thus positioning the two forearms the corresponding finger of each hand is brought opposite its fellow of the other hand and the resistance between each corresponding pair of fingers is rendered almost exactly the same as for that of any other corresponding pair. Unless this is done, a great deal more current will enter and leave the solution through the nearest pair of thumbs or fingers and they will become unbearably hot while the more distant fingers—due to increased resistance of longer stretches of salt solution—will carry very little current and not heat enough to do any practical good. Where a separate china dish is used for each hand and the circuit between the water in the two dishes is made through a strip of black tin, crookes metal or copper wire (the resistance of which is practically nil) the arms can be held in the natural position extending forward from the body, fingers dipping into salt solution, and the same results secured with much more comfort to the patient.

The necessity for a perfectly resonant high frequency machine is greater here than in most conditions. The use of a non-resonant machine will rapidly increase the misery of these patients to a point where they positively will refuse further treatments. Even where perfectly resonant machines are used, care must be taken not to overdo the treatments. The pressure from the active hyperemias induced—if the condition is far advanced—will sometimes cause terrific pain unless such hyperemias are kept within limits at first. The amperage (and the resultant amount of heat and hyperemia) usually may be increased after a few treatments. On the other hand we have had some extremely bad chronic cases that obtained relief almost from the first treatment. The sedative diathermia technic is used but the milliamperage will have to be kept rather low—three hundred to seven or eight hundred—on account of the

smallness of the cross section area of the parts as well as of the pathology. These almost bloodless parts offer a very high resistance and as the heat formed in a part varies as the resistance it can be seen that a given milliamperage here will produce much more heat than the same milliamperage through soft, fluid filled parts. Treatments should be given at least once a day to produce as much hyperemia as possible as often as practicable.

Ionizing doses of x-ray should be administered regularly, once every six or seven days, from the start of the treatment. The whole area showing any signs of overdose should be covered. The mistake of substituting a much harder ray and more filtration for the five inch back-up spark ray should not be made. The shorter wave length x-rays do not have the same action in these fibrositic conditions possessed by the longer wave length, softer rays. This we have proved clinically literally thousands of times. Some criticism has been made about subjecting these already sadly overexposed areas to further x-ray dosage. The fact remains that the small dosage recommended—even if not accompanied with other treatment to remove the effects—is decidedly beneficial. Go back over the history of the martyrs to x-ray. We cannot but be struck by the coincidence that those men who suddenly ceased using the x-ray and refused even to go into a room where it was being used as soon as they discoveerd that they had acquired a burn died much sooner than those men who, in the same circumstances, cut their exposures to a minimum but kept on with their x-ray work. The classical example is that of that wonderful pair of pioneer tube manufacturers, Green and Bauer, both of whom died martyrs to their work. Both acquired their burns at the same time, in the same manner, and from the same tubes. One ceased all exposure, *however small*, and died comparatively soon. The other cut his work to a minimum but did not cease his exposures entirely and his burn progressed much slower, giving him many more years of life than fell to his partner. Examples could be multiplied.

The painful condition of the parts usually forbids massage and manipulation at the beginning of the treatment, but these measures should be used as soon as permissible and carried as far

as the patient's tolerance will allow. By tolerance I do not mean to torture the patient to the limit of his endurance *during the treatment* but that massage and manipulation—to help break up the "frozen" condition of the parts—should be administered regularly and carried to a point short of producing excessively painful reactions in the tissues *after the treatment.* Both massage and manipulation should be begun *gently* and the force used *gradually* increased if the patient bears it well.

Static sparks (indirect, as sparks to hands are very painful unless intensity is cut down) are most valuable as is the static effluve. The sparks act in their characteristic "subsoiling" way to shatter the finer ramifications and help restore circulation and the effluve provides a high speed electronic bombardment that helps open up blocked circulatory paths and is very soothing to the patient. The patient usually acquires a tolerance for the spark very rapidly when he sees what they are doing for him. If we have access to both the static and massage we prefer the static to the massage but use the stretching manipulations in addition to the static.

When, by the intelligent use of these remedies, some measure of circulation has been restored and some degree of reactivity imparted to the atrophic skin, it is time to think of ultraviolet. Its use previous to this time is futile and calculated to discourage both patient and physician. This preparatory treatment—in the worst cases—may take months of time.

On account of the configuration of the hands it is impracticable to use a water-cooled lamp unless for certain ulcerative areas. The air-cooled lamp will treat the whole proximal surface at one exposure. Keratotic scales will have to be removed mechanically or by electro-desiccation or surgically as unless this is done the underlying tissue will receive no ultraviolet no matter which lamp is used. It is difficult to produce a heavy reaction upon these atrophic skin areas with the ultraviolet but unless this is done not much good can be expected to follow its use. When these areas have been brought up to a point where they will react to heavy ultraviolet exposures the battle is well on the way to a victory. Nothing short of the most intense ex-

posures will produce these reactions. If the water-cooled lamp is used it is used in contact or even, where tolerated, under compression for the first few treatments, at least over the worst patches. If the air-cooled lamp is used, the burner-skin distance should be as short as is consistent with safety, as the most valuable rays at this stage are the shorter ones and these are rapidly filtered out as the target-skin distance is increased. A seven inch burner-skin distance is the one we usually recommend as being the shortest routinely safe distance for use but in some of these x-ray burn cases we have not hesitated to approach to a four inch target-skin distance for a treatment or two. The heat from the burner is the limiting factor and the danger of a *heat burn* from long exposures at the shorter distance is a real one and must be avoided. Blisters do no harm but if the exposure is prolonged beyond the blister point an actual heat destruction of the skin may result.

As in acute burn, the ultraviolet exposures in chronic burn are preceded by from twenty to thirty minutes application of radiant light and heat from the 1500 watt bulb lamp. If the physician has any doubt as to how much ultraviolet exposure is safe with his particular ultraviolet burner, it is well to select a square inch of skin in an average area, cover the rest of the skin and standardize his dosage by treating this one area of skin, keeping an accurate record of all exposure dates, times and distances. Or, for instance, he might select three separate square inches, give the first square inch one minute at a four or five inch burner-skin distance, give the second square inch a minute and a half at the same distance and give the third square inch a two minute exposure at the same distance, allow forty-eight hours for the reactions to come up (on account of the low reactivity of these atrophic skins the reaction does not come up so fast as upon normal skins) and note the degrees of reactions upon the areas. When the blister point has been found then expose the whole area to an exposure just a half minute or so under the blister point, let the reaction clear up, remove dead epidermis and repeat again. Repeat at intervals until the whole area clears up, and give resistant areas more exposure as

needed by covering the faster progressing areas and concentrating upon the resistant areas with increased dosage.

The factor of grave blood changes has also to be considered in chronic burn cases. This destructive effect of too much exposure of the individual to x-ray or radium is practically always present in the chronic burn cases and tends to lower the efficiency of any reparative processes initiated or, if too far advanced, to reduce the possibility of initiating such reparative processes almost to zero. For several reasons, therefore, the administering of general ultraviolet to these patients is indicated. Probably no other single remedy in therapy has such markedly constructive effect upon local or general repair as has the ultraviolet light. This is all the more true when such lack of repair is due to a dyscrasia simulating pernicious anemia. The blood chemistry effect of general ultraviolet radiations —marked and beneficial as they are—are not the only ones to be considered here. It is a fact noted by numerous x-ray therapists that the production of a curative reaction upon one certain part of the skin is often followed by similar resolvent effects upon distal and—as yet—untreated lesions. We have noted, checked and used this fact in the use of ultraviolet reactions and the fact that ultraviolet reactions are *constructive* in character both locally and generally instead of destructive gives us license to use them over large areas at a time with safety and beneficial effects. There is little doubt in my mind, also, that this property of a reparative reaction upon one area of the skin favorably affecting dermatoplasia in distal parts extends to and includes the mucosa. A few second or third degree ultraviolet erythemas produced upon the healthy skin of gastritis cases will soon convince the most skeptical that this is true. I am simply noting this fact, which I have checked clinically on a large number of cases, without attempting to explain it scientifically. Much more research work will have to be done than can be done by any one carrying on in a huge clinic before the exact explanation of the reaction can be given, but we have made use of it for some years in many internal "itises." I am convinced that *general*

ultraviolet treatments are of benefit in acute burns, but I consider them *indispensable* in the treatment of chronic burns.

If any great degree of reactivity is left in the tissues when the case first reaches you or if such degree of activity can be restored to the areas affected by the preliminary treatments outlined, then a more or less complete clearing up of the chronic burn is possible, but if the process has been allowed to go to a point when massive fibrosis has practically frozen up all avenues of circulation then amputation may be the only remedy. Never advise amputation (unless in the presence of *undoubted* malignancy) until after a thorough, conscientious and intelligent trial of this method has failed as some of the very worst looking cases clear up and it is impossible to say, absolutely, from an examination which case will and which case will not clear up. Some cases already diagnosed as malignant will clear up. As long as there is an element of doubt as to the malignancy, this method offers the best hope of any conservative measures. We should be the last ones to advise temporizing with a *proved malignant condition* but our experience has been that many more x-ray burns are maligned than are malignant, although a few of them really are cancerous. We have added comfort in the fact that, even if the long-continued irritation has resulted in a malignant process the metastatic avenues are more or less sealed and extension is going to be much less rapid than in tissues not suffering from overdosage of the x-ray. If malignancy is present then all mechanical procedures such as static electricity, massage, manipulation, etc., are contraindicated from the start. If malignancy is even suspected, then the case should be sent to one of the larger research hospitals specializing in x-ray burn malignancy for immediate diagnosis.

CHAPTER XIV

GALVANIC AND FARADIC CURRENTS

The galvanic current, also referred to as the constant current, the continuous current, the direct current, is a low tension current and is grouped under the chemical division because its use (unmodified) in living tissues is *always* productive of marked polarity effects in the tissues immediately adjacent to the electrodes. The key to its rational use is a knowledge of these polar effects. If these polar effects are desired in accessible regions then this is the current to use, but if polar effects are not desired then the straight galvanic must be substituted by one of its modifications such as the reversing slow galvanic sinusoidal, etc. (See comparison interrupted galvanic and slow reversing galvanic sinusoidal in chapter on comparisons.) It is possible to obtain all the metabolism stimulating effects of the galvanic current without any polar effects—where these polar effects would do harm—by using the slow galvanic sinusoidal.

A comparison of the polar effects of the positive and negative poles shows that at every point they are diametrically opposed. A solution is said to be an electrolyte when it will conduct electricity. To do this the solute must at least partially dissociate into ions, and when this takes place the osmotic pressure of the solution is raised. Substances such as certain oils, fats, sugar, alcohol, chloroform, etc., do not ionize, do not give this increased osmotic pressure in solution and are called nonelectrolytes, or nonconductors. Acids, bases and salts are among the substances that ionize in aqueous solution. This dissociation of molecules or atoms into ions or into ions and electrons takes place automatically as the solute goes into solution and is not dependent upon the action of an electric current applied to the solution from other sources.

A few definitions will be given here to prevent constant reference to the chapter on definitions which would otherwise be necessary to those studying the subject for the first time.

Atom:	An uncharged atomic system. (Positive and negative charges exactly balanced.)
Molecule:	A combination of two or more atoms which has an exactly balanced charge.
	Note. (An atomic system or a molecular system may consist either of a balanced charge in which case they are called atoms or molecules or it may be an unbalanced charge in which case both are called ions.)
Ion:	An atom or molecule which has an unbalanced charge. (Excess of positive or negative electricity.)
Electron:	The smallest known, extremely minute corpuscle or charge of negative electricity.
Proton:	The positive charges of the nucleus of the atom have been named protons.
Ionization:	A breaking up or disruption of atoms or molecules into ions or into ions and electrons.
Nucleus:	The associated positive and negative charges, closely grouped, which form the central part of an atom.
Acids:	Electrolytes one of the dissociation products for which is a hydrogen ion. (H. Positive.)
Bases:	Electrolytes one of the dissociation products for which is a hydroxyl ion, (negative. OH.)
Salts:	Electrolytes neither acids nor bases.
Anode:	The positive electrode or terminal. The pole to which anions travel.
Anion:	An ion having a negative charge and thus being attracted to the anode.
Cathode:	The negative pole or terminal. The pole to which cations travel.
Cation:	An ion having a positive charge and thus being attracted to the cathode.

It is a law of electricity that charges of like polarity repel each other and charges of opposite polarity attract each other. The simplest way to prove this is to suspend two pith balls of equal size each to a yard or so of silk thread. When they are held suspended at the end of the silk threads so that they are in the same horizontal plane, as long as neither ball possesses any charge they may be approached towards each other or separated at will and the suspending threads will always hang straight down and the two will be parallel. Charge both balls positively and approach the strings together at the top. At a certain distance the two charges will exert a repellant action upon each other and the fingers holding the threads may be brought together until they touch but the two pith balls are now standing out in the air separated a certain distance. If forced together by insulated thread and released they will again return to this separation distance and hold this distance until the charge is lost. Discharge them and give one ball a positive charge and

the other an equal quantity negative charge. As they are approached now it will be seen that the balls are attracted towards each other and the distance apart at the bottom of the threads is much less than at the top at the point of suspension. If they are allowed to touch each other they at once resume position held by the uncharged balls in the first experiment. As a matter of faet they now are uneharged, as at the instant they touehed each other the positive and negative charges combined and neutralized each other.

Fig. 59.—Corner galvanic, faradic and sinusoidal section.

When a solute ionizes some of the ions are eleetropositive (cations) and some electronegative (anions). When a polarity current passes through the solution the cations travel toward the cathode and the anions toward the anode. Oxygen (acid maker) being an anion travels to the positive pole (prineipally in the hydroxyl ion OH) thus after the galvanic current has passed between two electrodes for some time the tissues adjacent to the positive pole become acid in reaction, while those immediately

under the negative pole become alkaline from the hydrogen-ion concentration. An acid condition of tissues tends to sedation and an alkaline condition to irritation, hence the positive pole is more sedative in character while the negative pole is irritating. The positive pole acts as a vasoconstrictor, hence has a tendency to check hemorrhage while the negative acts as a vasodilator and tends to increase hemorrhage. When the current is *condensed to destructive density* the positive pole acts as an acid

Fig. 60.—Corner galvanic, faradic and sinusoidal section.

caustic and the scar is a typical acid scar, dry, hard and contracting in character, whereas the negative acts as an alkaline caustic and the scar is the typical alkaline burn scar, soft, noncontractile and usually nonadherent. Where the current density is not pushed to the destructive point the positive dehydrates and hardens and the negative pole softens or fluidifies tissues. The action of the positive pole upon adjacent tissues tends to make these tissues an unfavorable media for the propagation of germs added to which the metals are cations and the positive

pole minerals are carried varying distances into the tissues forming germicidal compounds whereas the negative terminals are not acted upon in that manner and the liquefying and the softening action of the negative pole prepares the finest kind of a field for the propagation of germs. This is true more especially if full length, full strength treatments are given. With this proviso it might be said that the positive pole is somewhat antiseptic in character whereas the negative is septic or tends to

Fig. 61.—Corner of galvanic ionization section.

produce septic conditions, therefore its use in cavities or places where infection or absorption is liable to take place should be followed by antiseptic measures.

Knowing the polar effects it is necessary to have a knowledge of the nature of the charge carried by the various ionized substances. A glance at the definition of acids and bases shows that acids, acid radicles and bases are anions. We are aware that some text books upon electrotherapy state that bases are cations but the definition shows that the identifying ion in the ioniza-

tion of bases is the hydroxyl ion O H, which is an anion. The halogens are anions also. The cations are metals and hydrogen. It is not necessary to print long lists of the electropositive and electronegative qualities of individual ions and such lists would not serve as well as the shorter general rules. Among the salts, the alkaloids (alkalie-oid—similar to alkalic) are cations as are the alkalies, while the acid components of the salts are anions. Thus if you wish to use the alkaloid content of cocaine hydrochloride, morphine sulphate or quinine bisulphate, etc., you know that you must use the solution from the positive pole—from which the active principle is repelled—as if you used it from the negative pole it would stay on the electrode to which it is strongly attracted.

Deep ionization with the galvanic current is not practicable as is easily proved by attempting to do an operation under cocaine driven in from the positive pole. If the application be properly made the skin may be completely anesthetized, but when the knife reaches the subcutaneous tissues it is found that no anesthesia is present or at least not enough to do any good and resort must be had to the needle. The reason is not far to seek. The fastest of the ions, the hydrogen, travels at a very low rate of speed. The cocaine ion is many times slower. The greatest concentration of the ions is of course in the tissue nearest the electrode but as they penetrate the high resistance skin and reach the comparatively extremely rapidly moving blood stream, they are simply swept away and the current travels from there on by way of the very much faster moving and better conducting ions such as hydrogen and hydroxyl. In extensive scars, where the circulation is almost absent, much deeper ionization can be done provided the current is applied in such a manner that it cannot shunt around the scar and provided a proper technic is employed. The rate of travel of the ions will vary with their atomic weight and the number of water molecules that they attach to themselves and carry along with them, but can be accelerated by increasing the voltage impressed upon them—the higher the voltage, the greater the speed. It has been found from practical experience that long treatments with rather small milliamperage are better than short treatments with high

milliamperage. It has also been found that a moist, finely pulverized clay electrode, moulded to even thickness and conformity to the scar area makes a better adapter electrode than a rigid one or one made of soaked cloth or gauze. A piece of copper screen wire can be cut to cover the top of the clay electrode, cutting it so as to make it slightly less in diameter than the clay electrode. A good way to attach the negative galvanic wire to this is to cut the screen to shape to the back of the electrode,

Fig. 62.—Applying moist, moulded pulverized clay electrode to adherent scar preparatory to giving a negative galvanic ionization treatment. Two per cent salt solution was used to moisten the clay. Note cord from negative pole attached to back of clay electrode by a clip snapped onto a copper screen backing imbedded into the back of the clay. In practice the clay was first applied and moulded to shape and proper thickness and then the copper wire backing applied, bandages put on and the cord attached to the projecting clip. To show the whole operation in one picture this procedure was changed.

leaving a narrow strip of the screen extending from each of two opposite sides slightly more (about ½ inch) than half the diameter of the wire back at that point, fold these two narrow strips across the back of the screen until they meet, bend the two ends up at right angles where they meet in the center, clip a eureka

spring clip electrode attachment onto these ends, press the wire back firmly onto the clay; bandage on, leaving the clip exposed and stick the negative cord tip into the receptacle of the eureka clip. The other indifferent electrode can be placed at any point where its positive polarity will not interfere with the work in hand, care being taken not to place it at too great a distance on account of increasing the resistance too much. One supply of this finely pulverized clay (fine potter's clay is good) can be used over and over if it be kept in a closed container. When used it can be placed in another closed container and when enough used clay accumulates it is easily sterilized by placing it in an autoclave. Care must be taken not to place it in the autoclave in an open pan else it will come out as hard as brick and unfit for further use. A way we used successfully for years was to place it in wash basins, inverting another basin of the same size over it to retain condensed steam. This top basin must *not* be fastened down firmly (unless it has a small hole in it) for fear of the steam formed between the pans causing an explosion. After trying many kinds of solutions of many strengths we found that a two (2) per cent sodium chloride solution gave us as good results as any of the more expensive ones and we used this to moisten the clay as needed. The clay should be moistened enough to lower its resistance but not enough to make it too thin to mould easily. The use of moist clay gives much better adaptation to the uneven surfaces and permits of the use of slightly higher voltages than that of compresses, felt, electrodes, etc.

The determination of the polarity of a given conducting cord is a simple procedure. Moist litmus paper may be used but is not always at hand when wanted. Take a glass of hydrant water, place the two cord tip terminals in the water an inch and a half or two inches apart and turn on the control rheostat until the meter shows passage of current. Hold the tips perfectly still for a few seconds and observe the gas formation on the cord tips. The hydrogen, traveling to the negative pole, forms almost exactly twice as fast as the slower traveling oxygen collecting at the positive pole, so that the pole forming bubbles of gas the fastest is the negative. Test the polarity frequently unless you

are using the galvanic current from an outfit with a generator built into it and all connections permanently made or unless you are using cells. In these cases the polarity is always the same to a given cord unless there is a polarity changer switch on the outfit in which case a glance at this switch will tell which cord is positive and which is negative. If a wall plate with a flexible cord running to a socket (direct current line) is being used or if a motor-generator set (A. C. current motor driving a direct current generator) is used with a flexible connecting cord running from the set to the control board then constant care must be taken to avoid reversing the polarity to the wall plate and so to the patient. Every split socket connector should be watched or marked in such a way that it is *always* put together the same way. If the connection to the board itself is the usual flat plug with two holes in the end of it to slip over two projecting metal studs then mark the upper side "top" and always put it on with this side up. If these precautions are taken it will save much confusion and use of wrong polarity. If the board is properly wired the galvanometer needle will deflect towards the positive cord. That is, if the needle travels to the right the right cord will be positive and if to the left then the left cord is positive. If the board has a one way scale meter then, of course, the meter will not register when the rheostat is turned on unless the polarity of the current entering the board is correct. If, when the rheostat is advanced, no meter reading is obtained—if you are sure that there is no open circuit anywhere—or if the needle tries to go back past the zero mark, turn the rheostat back to zero, disconnect the cord where it plugs into the board, turn it over one-half revolution and connect it and the polarity entering the board will be correct.

Some years ago we were very much startled when a visiting physiotherapist and teacher of electrotherapy was going through our clinic to hear him ask the chief galvanic and sinusoidal section aide which polarity was being used in a scar ionization. She was one of the finest trained galvanic aides we ever have had associated with us, holding two college degrees and being a keen student of physics. She answered that the scar electrode

was delivering the negative current and he gravely stood there and told her that she was mistaken because she had the red cord attached to the scar electrode and she could not possibly be delivering the negative polarity as the negative would only travel over the *green* cord and that the red cord was *always* positive, etc.

Ionization of scars is necessarily a slow process. The treatment should be given daily or nearly so as possible and the electrical treatments supplemented by diathermia, baking, whirlpool, judicious massage, stretching exercises, etc. If parts of certain muscles or tendons are bound down, then the stretch may be produced by the stimulating of as vigorous contractions in the muscle as can be borne comfortably by some of the surging modalities or the Bristow coil. For deep ionization we use the ionizing x-ray dosage once every five, six or seven days. After a couple of weeks treatment we often substitute diathermia for the baking or whirlpool with benefit. We have seen visible loosening up of scar tissue in as little as three weeks and we have seen cases resist all treatment for a period of several months and then gradually loosen up. It is almost impossible by looking at a scar to tell anything accurately of its extent. A comparatively slight skin scar may cover a tremendous amount of deeper cicatricial tissue and vice versa. Make it a rule where any scar is giving rise to pain or limiting function to give it a trial anyway and sometimes results will be surprising. We have never been able to secure any such good results from the use of thiosinamin solution from the positive pole in the attempt to remove scar tissue as we have obtained by use of the sodium chloride-negative pole combination.

After all electrodes are applied, secured, connections made and the operator is ready to turn on current, care should be taken to move the rheostat lever or turn the button *slowly* and steadily. Any sharp surge of current is very painful. Especially is this true if the treatment is being given on a mucous surface. It is barbarous, when the time of application is up, to reach over, give the rheostat lever a flip and send it to zero. This administers a very painful and perfectly needless shock to

the patient. The lever should be turned back even more gently than it was turned up at the beginning of the treatment.

In treating scars upon the head or administering galvanism through the brain the avoidance of shocks is particularly necessary. I prefer a dry cell galvanic battery to a line current for this kind of work as there may be sudden drops of voltage on a line due to blown fuses, repair men breaking a connection, etc., or, as I have seen, a trouble shooter may pull out a fuse or switch at a distance and almost at once replace it, thus giving a brain case two very bad shocks, one right after the other, and possibly causing dangerous syncope. Caution is necessary in any case where galvanism is being sent through the head, but a great deal more so when the current is being sent through from side to side. Much less current is tolerated laterally than anteroposteriorly. I have seen syncope result from as little as two milliamperes being given from side to side and from six and eight anteroposteriorly. I certainly would advise against any such enormous milliamperages as are sometimes recommended, offhand, in discussions on galvanic papers.

In doing epilation of individual hairs with the needle and negative galvanic, a dry cell current will be found much more pleasant and quite as efficient as the higher voltage currents from a main. A small amount of current—usually about one milliampere—for a longer time is better and stirs up less pain and reaction than larger milliamperages for a shorter time.

FARADISM

The faradic current is an induction current produced by passing an interrupted galvanic current from dry cells or the mains through an interrupter and into a primary coil placed in inductive relation to a secondary coil. Without the interruptions the circuit carrying the direct current would have no inductive properties except at the instant the current was started and stopped and so no current could be obtained from the secondary. Diagrams showing the construction of a faradic coil may be found in almost any elementary work on electricity and will not be included here.

The character of the current varies with the voltage, amperage and frequency of interruptions. Most of the faradic coils have a secondary of very many turns of fine wire and have a comparatively fast rate of interruption. The voltage, of course, is regulated by the ratio of the number of turns of wire in the secondary as compared to the primary, the greater this ratio the higher the voltage. In the Bristow coil the wire of the secondary is large and the number of turns in the secondary much reduced. The lower voltage ratio of transformation and the lower resistance of the large wire give the output from the secondary a higher amperage than that of other faradic coils and with the slower rate of interruptions gives it a peculiar value in developing muscles where regeneration has progressed to where it will take hold. In the reaction of degeneration the response to the Bristow coil is the first reaction lost and the last one regained in the reaction of regeneration. The motor point reaction to the higher voltage faradic current is lost after that to the Bristow in the R. D. and regained before it is in the reaction of regeneration so that this fact becomes a diagnostic test as to the stage of either reaction.

Except for testing purposes the higher voltage faradic is not used nearly so much as formerly. The Bristow coil, the Morse Sine Wave Generator, the static condenser discharge and the surging sinusoidal wave are used where it formerly was used. Where any form of muscle exercise through motor point stimulation (as in developmental work in relaxed sacroiliac, flat foot, etc.) is used, it is well to remember that the object should not be to get as much work out of the muscle in as short a time as possible, but rather to start in easy, with rest periods between the contractions induced and, as the muscle picks up under the exercise, gradually to increase the intensity of the contractions, increase the amount of work and if thought advisable decrease the amount of rest between contractions. The practice of operators *binding on* motor point electrodes, sitting with a book or magazine in one hand and nonchalantly and industriously pumping the core of a Bristow coil in and out (the way surges of current are produced) with no attention to patient and all for the book, or, worse, of allowing or compelling the patient to do

the pumping himself while the operator reads, may be a fine tribute for the fiction author but is poor business for the clinic. Such evidence of indifference and careless technic in one part of the clinic is sure to react upon other parts and, if not properly checked, distinctly lowers the morale of both operator and patient.

Due to the easy portability of the faradic battery it comes in useful in a number of ways that will suggest themselves. One of the most grateful applications that can be given some of these

Fig. 63.—Faradic massage. One electrode under patient's abdomen and the other under the bandage on operator's right arm. Current intensity regulated by operator's tolerance, current just short of the amount that would contract her hand beyond her ability to do the massage movements.

bedridden "muscular rheumatism" cases (be sure that it is not an acute neuritis) and one that will often enable them to come to the office after a very few treatments is a faradic massage of the myositic area. If you have a portable radiant light applicator ("baker") then precede the treatment with fifteen or twenty minutes of radiant light and heat over the area to be massaged. Apply one large electrode under the patient and the

other cord to an electrode on the forearm of the masseur. The hand of the masseur is laid upon the patient and the current turned on with the other hand. The limit of current is usually the amount that will enable the operator to use his hand without producing such contractions of his own muscles as to prevent him from massaging the patient. The patient almost always will tolerate more current that the operator can use. The massage is performed as usual, of course care being taken not to lift the hand being used off the patient and so break contact. A variation is to use the rheostat lever or the core if a Bristow is being used to produce surges, the operator placing his fingers along the muscles to be rhythmically contracted and produce the surge by turning on current to tolerance and then decreasing it, resting a moment and repeat, etc.

CHAPTER XV

THE SINUSOIDAL CURRENT

A sinusoidal current is a current the voltage tracing (oscillograph) of which resembles a sine or a segment of a circle. The rapid sinusoidal current is the ordinary commercial alternating current and a voltage tracing of it would show as many positive and negative sines as there are cycles per second. A cycle is one complete positive and negative phase. A twenty-five cycle a second current has twenty-five complete cycles a second; a forty cycle, forty per second; a sixty cycle, sixty per second; a one hundred thirty-three cycle has one hundred thirty-three complete cycles, etc. A complete cycle is the time elapsing from the start or zero voltage point of a positive voltage variation, through the rise and fall of that positive variation and on through the negative variation which follows it and corresponds in intensity, time, etc., but which differs from the positive only by having the opposite polarity. In a sixty cycle current this complete positive and negative voltage rise takes place in $\frac{1}{60}$th of a second and is repeated sixty times a second. A voltage tracing of one complete cycle of the commercial 60 cycle rapid sinusoidal would appear as follows where the 0 would represent the zero voltage level, the vertical line the voltage rise and fall and the linear horizontal distance the elapsed time.

Each positive phase is immediately succeeded by a negative phase of equal intensity, therefore the rapid sinusoidal current displays no polarity effects and is rated as a mechanical modality. This is also true of the slow galvanic sinusoidal current.

The rapid sinusoidal current is used either straight (controlled through a rheostat) or modified by being run through a rotor (fixed resistance unit with moving brushes) or some similar appliance which by evenly raising and lowering the resistance converts it into a surging wave. The double voltage variation of this wave makes it very stimulating. The Morse Sine Wave Generator is an adaptation of this principle except that they

have carried the stimulating properties of the surge still further by having the cyclage increased to several times the 60 cycle frequency. The surging rapid sinusoidal current is particularly valuable in stimulating relaxed or atonic musculature and its use is indicated over a wide range of conditions. Care should be taken never to use it in any intensity through or near the heart muscle itself.

The slow galvanic sinusoidal is the straight galvanic current modified by being run through a constantly and evenly varying resistance which is so constructed that each succeeding wave is of the opposite polarity to that of the preceding one. All polarity effects are thereby neutralized. This can be done by having a fixed resistance block with rotating brushes (as in theMcIntosh Polysine Generator or Universalmode), by having fixed brushes and a revolving resistance (as in the Victor Multiplex) or by having a fixed resistance with a sliding contact actuated by a cam and arm arrangement, (as in the Wappler and others). It is quite essential to have independent voltage and sine wave speed controls so that a high voltage, low speed wave or a low voltage, high speed wave or any modification of the two can be obtained. Sturdiness of construction is another thing to be considered. Perhaps no harder test of endurance was ever staged than that which took place in the Fox Hills Hospital where peripheral nerve injury paralyses were sent in to the physiotherapy service for treatment in such numbers that nine outfits of one make, eight of another and four of various other makes were kept going all day every day and waiting lists were always posted by each machine of men to receive treatment as soon as vacancies occurred. Soon after this load was thrown onto the sinusoidal section, casualties among the machines began to occur. It was not long until it was demonstrated that only three stations could be kept going continuously with the nine outfits of one make because of frequent breakdowns. The other six were either in the repair shop or those that had been repaired had to be held to replace the frequent breakage on the three regular station machines. Of the eight machines of another make we were able to maintain seven regular stations and more than half the

time an eighth station. In addition to being much more sturdy, the eight had a very much better variation of controls and selection of modalities. It is, of course, hardly a fair thing to expect *any* appliance to stand up under such a gruelling test and yet one make of outfit did it and very much exceeded our expectations, whereas the only thing we could bank upon on the other was that it would be out of order two-thirds of the time.

The lack of polarity effects, the very much less pain incident to its application (allowing the use of many times the volume or milliamperage), the fact that paralytic muscles respond earlier and better to slow impulses than to fast ones, and the more nearly normal contraction that takes place in weakened muscle under its use make the slow galvanic sinusoidal the modality of choice

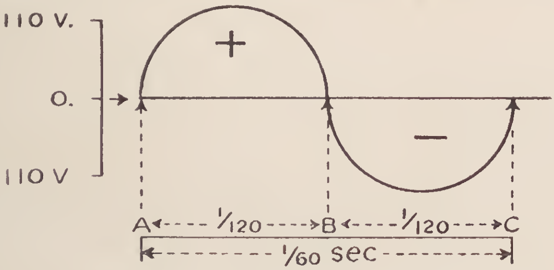

Fig. 64.—*A* to *B*—Positive phase. *B* to *C*—Negative phase. *A* to *C*—One complete cycle.

in developing paralytic muscle when the stage of response to irritation is reached. A comparison of the use of the slow galvanic sinusoidal and of interrupted galvanism in the treatment of peripheral nerve injury paralyses is given under the chapter "Comparison of Interrupted Galvanic and Sinusoidal Currents." A voltage tracing of the wave of the slow galvanic sinusoidal current would have exactly the shape and characteristics of that given for the rapid sinusoidal current except that the elapsed time for each wave would be very much longer and the voltage would only rise to the limit set by the main control rheostat. The voltage that is allowed to enter the wave producing mechanism (rotor) is governed by the setting of the lever on the main control rheostat through which all current going to the rotor must first pass. If this

main rheostat is set to allow 30 volts to pass through, then the slow sine wave would be a positive and negative phase each of 30 volts, etc. If the speed control of the wave producing mechanism were set to run, say, thirty revolutions per minute, then there would be thirty positive and thirty negative phases each minute and a complete cycle would occupy two seconds of time and the positive and negative phase each would occupy one second. If the rotor were set to revolve sixty times a minute then a complete cycle would require one second and each of the two phases a half second, etc. A detailed illustrated description of the mechanism for producing these sine waves cannot be given here, as to describe all the different makes would consume too much space. The makers of sinusoidal apparatus are glad to furnish booklets giving these details with illustrations so that that obviates the necessity for reproducing them here. Suffice it to say here that the *slow* sinusoidal current is not some mysterious thing generated from some special generator, like the static machine for generating static currents, but is the straight galvanic current modified by being put through an evenly varying resistance which delivers the current to a given electrode in symmetrical waves, the rhythm and intensity of each wave being exactly the same but the polarity of each succeeding wave being reversed. Thus you would have delivered to each electrode a positive wave immediately followed by a negative wave, then another positive, another negative, etc. Some of the slow sinusoidal outfits are called generators and do have a generator built into them which gives an earth-free current and so makes their use around hydrotherapy appliances much safer, but the current generated by this generator is the straight galvanic current. After being generated in the motor-generator set on the appliance, it is led through the various accessory controls and made into the reversing polarity waves known as the slow sinusoidal.

In view of the fact that the commercial alternating current is often called the sinusoidal current and that readers of articles upon the sinusoidal current are often utterly unable to determine which current is meant unless it is specified in the article itself,

it should be made a rule of practice for an author to state just which current he means. The terms slow and fast can be made to characterize the sine waves from a slow sinusoidal machine and the term rapid be left for exclusive reference to the commercial alternating current where the waves change twenty-five, forty, sixty or one hundred and thirty-three times *per second* instead of a few times per minute as with the slow sinusoidal. Unless this is done, endless confusion is bound to arise. In fact, it has arisen already. From some of the statements made a suspicion enters our minds that some of the authors are "paper experts" (i. e., that they became "authorities" from studying some more or less authoritative writings of some one else and then try to fit their deductions to actual cases) and could not tell which they meant themselves if they were asked. This state of affairs is by no means confined to the sinusoidal field. It is not unknown to find that an announced lecturer upon a very complicated subject first *heard of the subject* less than a year previous to his lectures and, possibly, has not had any clinical connections at all or even a private practice from which to draw the necessary experience. The nerve of some of these foremost authorities is only exceeded by their own ignorance of the subject. It is hardly necessary to state that they always take some other man's technic, twist it around, camouflage it, "improve" it, and put it forward under their own names. If they are bold enough to try to invent a technic outright, the result is something so weirdly wonderful that the wonder is that it does not work. These impractical theorists never last long, but each one makes the work of those who have given their life's best efforts towards simplifying and making efficient the various technics connected with the successful administration of physical remedies much harder because they attain great publicity, *prove* to men studying the subject for the first time and attempting to follow their wonderful technics that certain remedies *are* inefficient, etc., try in various ways to discredit practical procedures and in many things add to the confusion and prejudice already existent. Fortunately, it takes more than hot air to disprove a technic founded upon years and years of hard study of the basic

physics involved and proved by clinical use upon, literally, thousands of cases and, so far, hot air is the only disproof any of them have offered. Josh Billings once had one of his characters enunciate a great truth which applies with *deadly* accuracy to the therapeutic field. He had this character say, "It ain't ignorance that is the trouble with this world. It is having so darned many people what know so darned many things what ain't so" or words to that effect.

Fig. 65.—Two stations in a corner of the sinusoidal section. Patient receiving selective motor point stimulation. Treated for months for an old osteomyelitis, then operated (nerve suture) and the fibrosis of elbow and hand broken up under diathermia, static and ionizing dosages of x-ray plus forcible manipulations. This shows a terminal stage in his treatment.

On account of the reversing polarity of each succeeding wave neither the slow nor the rapid sinusoidal current gives polarity effects. This is a distinct advantage as, if we wish polarity effects, we can obtain them from the use of the unmodified galvanic current. For this reason the sinusoidal currents are grouped under the mechanical section in physiotherapy. They

are used principally to improve tone in musculature by exercising, to aid in removing sequelae of fibrositis (vigorous massage of prostate, for example, following diathermia and where a static condenser discharge is not available) to improve local nutrition when given in quantities below that necessary to provoke contractions in contractile tissue, etc. The only cautions necessary are to avoid overworking muscles and to keep away from the heart muscle because of the danger of producing fibrillation and to avoid regions where recent fractures or presence of virulent infective material, malignancy, etc., makes any massage or movement of the parts inadvisable.

A technic for the proper use of the slow sinusoidal in developing paralytic muscles is given in the chapter on peripheral nerve injuries. This rigid technic is not so vitally essential when treating more or less healthy musculature for developmental purposes but it injures even a healthy muscle to overwork it so that I advise against the practice of binding on an electrode over a motor point, turning on the current to tolerance and giving "twenty minutes." I am aware that this procedure is a very common one and have been told repeatedly that it has always been done that way but, in spite of the good results that have occasionally followed its use in this manner, it is wrong. Choose the muscle or group of muscles you wish to develop, determine the amount of exercise that would be beneficial to them, *see that they get it* and not *their opponents*, and increase the amount of treatment as they gain in tone. Never neglect to locate the cause of loss of tone. For instance, in flat foot, if the original cause was loss of tone of the muscles from a slight neuritis of a motor nerve (infective, traumatic or otherwise) the neuritis has to be removed by appropriate treatment or else much of the labor in developing muscles, exercises, orthopedic appliances, etc., is lost. The rule of sudden voltage variations being more stimulating than slow ones holds here and the surging wave where the *rapid* sinusoidal is made into a surging wave is even more stimulating than the slow sinusoidal.

CHAPTER XVI

COMPARISON OF INTERRUPTED GALVANIC AND THE GALVANIC SINUSOIDAL CURRENTS

A controversy has been raging for many years over the comparative merits of the interrupted galvanic current and the slow reversing galvanic sinusoidal current in the development of weak or paralytic muscles. When the flood of nerve injury paralyses from the late war poured into the various reconstruction clinics and overflowed into many private clinics an opportunity was offered to try them out one against the other on a scale larger than ever before dreamed of. The verdict in favor of interrupted galvanic was so nearly unanimous that we almost lost caste for a while on account of our contention that the proof was absolute—not in favor of interrupted galvanic current but against it.

Either through personal visits, aides being transferred into our clinic from other clinics or from our clinic to the others, we were in touch with the methods used in those clinics and soon found out the reason for the almost unanimous preference for interrupted galvanic. To our surprise they were being tried out against each other with identically the same technic being used in both cases, this technic consisting in binding an electrode on over a motor point (or if several happened to be in the area of the electrode, then over several) and giving "twenty minutes" of current to the favored motor point or motor points. If the trial is to be made under such conditions then I will save argument and admit that the interrupted galvanic is *vastly* superior for use in these conditions. I am not making this comparison for personal reasons and would not make it at all were it not for the fact that ever so often we are confronted by some medical man who *knows* that we are wrong because *he saw* the two tried in some clinic where he was on duty with *everything* in favor of the interrupted galvanic current.

The interrupted galvanic outfits supplied for use of the various government hospitals are, in reality, not interrupted galvanic outfits at all, because before a current can be *interrupted* it must *be passing*. These outfits, to be brief, are instantaneous make and break outfits and only deliver a current to the patient when a clockwork actuated cam or contact point in its revolution touches a stationary point so that the circuit is only closed momentarily and is immediately broken until the next revolution brings the cam to contact again. No current passes at any other time except at this almost instantaneous contact. This means that in a twenty minute time period about six seconds of actual work is imposed upon the muscle, each period of work being separated from the next by at least several hundred periods of rest. The pain from such abrupt makes and breaks is so intense that only small currents can be used. Muscles that have been paralyzed as a result of nerve injury, when *they do* begin to respond to motor point stimulation, respond much better to slow stimulation than to rapid, and the intensity of the response is in relation to the volume of the current as well as the change in voltage, so that it can be seen that a current having only just voltage variation fast enough to cause contractions is better and will cause response in muscles much nearer total paralysis than much faster rate interruptions will and a gradual voltage change such as that in a slow sinusoidal wave will be so very much less painful than higher voltages and amperages can easily be used than is possible on the interrupter so that *stronger* contractions of a more physiologic character are produced by the galvanic sinusoidal. The first point is proved by tests with the muscle testing condenser set. At first it takes a slow discharge to get any response at all and, as the muscle gains tone, shorter and shorter discharge times (irritation of motor point) will produce a contraction until when the normal is almost reached the muscle will respond to irritation periods only one or two per cent as long as at first required. The second is proved by any tetanizing current—the greater the amperage at a given voltage the more violently traumatic is the passage of the current through contractile tissue. But, the greater the voltage variation the more irritating the current (short of high fre-

quency), so that when both amperage and voltage are increased, two additional efficiency factors are added. This point is also easily proved by the muscle testing condenser set—raise the charging voltage a few volts and contractions can often be produced where the same capacity at lower voltage would not produce them. Thus it can be seen that there are several reasons why the slowly changing voltage wave called the slow sinusoidal is better for use in these cases. It will, due to its slowly changing voltage wave, affect muscles that the interrupted galvanic with its instantaneous rise and fall of voltages will miss. It is so much less painful that both higher voltage and higher amperage can be used, both factors in efficiency, thus making the treatment pleasant instead of an ordeal and increasing the efficiency at the same time. It produces a contraction of greater intensity but, on account of its slow wave form, one more nearly physiological and, therefore, therapeutically to be preferred.

Now let us see what a real interrupted galvanic does. On a real interrupted galvanic outfit the current is collected through a brush riding on a ring somewhere in series with the patient. This metal ring is broken at one point and a piece of hard rubber or some other nonconductor inserted flush with the ring surface so that when the brush leaves the metal ring and rides onto the nonconductor the current is broken and as the brush passes off this rubber back onto the metal the current connection is again made. The ring is usually made so that the current passes 80 or 90 per cent of the time. Here the make and break is instantaneous also and subject to the same pain limitations as the other clockwork form, but between the interruptions there is a flow of constant polarity current giving polarity effects which certainly are not wanted in these cases, so that a real interrupted galvanic current is less desirable than a rheotome interrupted one.

The reversing slow sinusoidal does not give any polarity effects, does give all the metabolism stimulating effects of the straight galvanic minus the polarity effects and has all the above recorded advantages.

So much for the currents. Now let us examine technic a

moment. When a clockwork rheotome interrupted current is being given to a weak muscle through its motor point, the muscle is receiving an impulse that causes it to do one period of light work with several hundred periods of rest between each period of work and the next one. Even twenty minutes a day of this exceedingly light work is not enough to tire out and damage a muscle "coming back." The same would hold for a *real* interrupted galvanic outfit although the latter, due to its construction, would deliver hundreds of times the *amount* of current with its undesirable polarity effects in the same period of time, but would cause very little more muscular work due to the fact that *variations of voltage only* are effective in causing contractions and contractions would occur with about the same regularity as on the rheotome outfit. With the slow galvanic sinusoidal what a different state of affairs! Here we have a current that is passing *all the time*, except at the moment when polarity reverses, that is varying in voltage every instant of the time therefore working the muscle constantly, and not only on the job hundreds of times longer in a given time than either of the other currents, but working the muscle harder each instant of the whole time with practically no rest from start to finish with more current of a more efficient character. If a current causing one part of light work to several hundred parts of rest for twenty minutes is a proper dose, then several hundred parts of heavier work to no parts rest is certainly improper. If "twenty minutes" is a proper dose for one motor point then why not develop all muscles alike and give *each* motor point (and its muscle) the proper dose and not play favorites. Obviously this would consume quite a bit of a busy man's time so it is easier to say "twenty minutes" and let the technician place the electrode. Fortunate, indeed, were the patients in such clinics that it took only one or two "comparisons" to demonstrate the superiority of interrupted galvanism. Twenty minutes of the slow galvanic sinusoidal current over a healthy muscle motor point might very greatly damage such muscle and—well, what we think of subjecting a *weak* muscle to such treatment cannot be reduced to print.

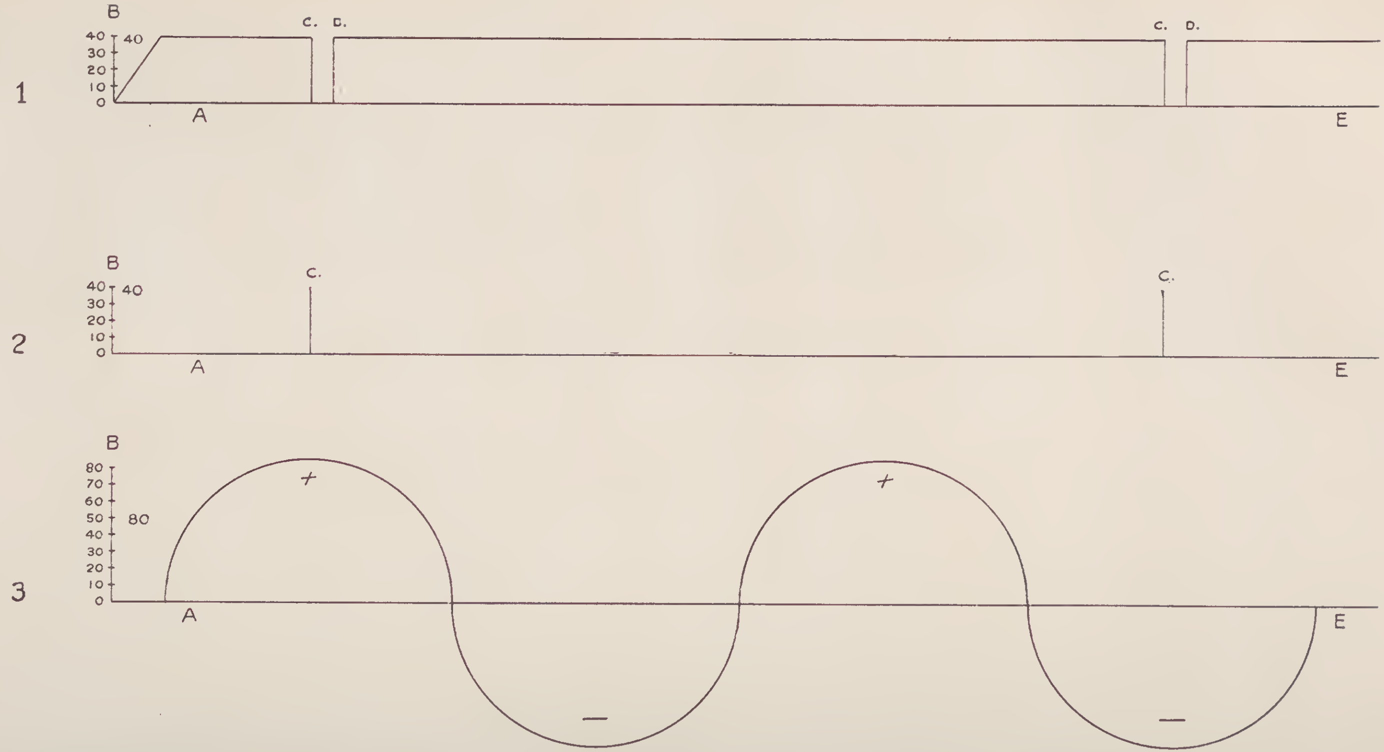

Fig. 66.—Diagrammatic representation of voltages and duration of time of current flow in interrupted galvanism and the slow galvanic sinusoidal.

1 represents the flow of current on a real interrupted galvanic outfit. Current flow is interrupted at C and voltage falls to zero. Contact is made at D and voltage rises again to flow until again interrupted at C. This type of outfit gives polar effects.

2 represents the instantaneous make and break of the current at C and C. No current is passing to the patient at any other time and the contact is so brief that no polar effects are noted.

3 represents a voltage tracing of the slow galvanic sinusoidal. Current passing practically continuously, more voltage and amperage and much less painful than either of the other two. No polar effects.

Used with a *compensated* technic—equal working time under each current—there will never be the slightest doubt in the mind of *any unprejudiced observer* as to which current is the most beneficial.

A graph voltage tracing of the three currents would show about as follows: The abscissa or horizontal line representing time and the ordinate or vertical the voltage rise.

1. Int. Galv. from real Int. Galv.
2. Int. Galv. from rheotome Int.
3. Slow Galv. Sinusoidal

Numbers two and three would be rated as mechanical currents as the duration of actual current passage in No. 2 is too short to manifest polarity effects and in No. 3 each half cycle neutralizes any polarity effect of the preceding half cycle. The motor point electrode on No. 1 would give marked polarity effects unless—as is not done on American apparatus—some provision was made for alternating the polarity at each interruption and would be classed as a chemical modality.

CHAPTER XVII

PERIPHERAL NERVE WOUNDS

In order to keep the present work down to practical size I adopted a policy of omitting all matter except *treatment technic* and, insofar as possible, confining myself strictly to the physiotherapy end of such treatment. I am not going to consume a hundred pages or more in giving diagnostic tests, differential diagnosis syndromes, surgical advice, etc., on nerve injuries. These have all been covered in earlier works much better than I could cover them. For those wanting detailed instructions along these lines I heartily recommend a study of that classic upon this subject, Tinel on "Nerve Wounds" (Wm. Wood & Co.) or some of the later works by some of the surgeons who had such a wonderful opportunity of studying these cases upon a mammoth scale. It is assumed that surgery has been or will be used wherever indicated. It is in the treatment of old cases before and after neurolysis, graft or suture and new cases after crushing or suture operations where proper physiotherapy proves invaluable. In nearly every case my own technic differs from that formerly used and in no case is this more true than in the treatment of nerve wounds and their sequelae.

The difference between my method of treating these lesions and other methods is basic in character. Researches by many men have proved the almost complete inefficiency of massage and galvanic stimulation (the basis of all other methods) in the early stage treatment of these nerve injuries. I shall quote only one such, but it is one of the best and is typical in every way. All have pointed the same moral. In a paper "Treatment of Denervated Muscle" published in *Jour. Am. Med. Assn.*, March 27, 1920, p. 878, by Frank A. Hartman, Ph.D., and W. E. Blatz, M.A., giving results of a research done in the physiology laboratory of the University of Toronto under the auspices of the Research Committee, Medical Services, Department of Militia and Defense, Ottawa, Canada, the authors state among

other relevant facts: "We have examined the denervated muscles in three rabbits before and after massage periods ranging from five to twenty minutes (the skin always protected the muscle while it was being treated). There was no apparent reduction in the fibrillation. A similar study of fibrillation before and after galvanic stimulation in six rabbits has shown in no instance anything better than a transient reduction.

"In the light of our present researches, we believe that mas-

Fig. 67.—Testing for progress in a nerve injury case after regeneration has taken place. Lewis Jones muscle testing condenser set being used. To save time and space the lighter ionization outfits were hung upon the wall and the heavier sinusoidal outfits placed upon small tables between the treatment tables. The nerve injury section of the clinic was always full and had waiting lists most of the time.

sage in denervated muscle is futile. Galvanic treatment likewise appears to produce no beneficial effect" and later in the summary: "In all of our work we have been unable to demonstrate benefit from massage or galvanic stimulation." (They used 123 rabbits in the series.)

Why did this research and all other properly conducted ones

using the same remedies result in the verdict that "massage and galvanic stimulation" were of no real value? Why was a "temporary" reduction in fibrillation noted after the application of stimulating galvanic shocks? What is fibrillation? What causes it and what does it cause? Let us start on the last question first and try to see why all such treatment is wrong in principle and practice. Fibrillation is a quivering or a succession of very rapid contractions of muscle fibers. When Langley brought out the fact that atrophy of muscles (and the later fibrosed state) was due to the fibrillation which always follows severance of the nerve, his announcement showed exactly why all such treatments were futile. Stimulation overdone becomes irritation and *intense* irritation is what we have in a denervated area. This intense irritation alone would kill the muscle from constant overwork but in the face of the twenty-four-hour-a-day labor the muscle is now compelled to do, the nutrition of the muscle is markedly lowered by a partial ischemia. Thus instead of much increased blood supply that would at least help minimize the damage we have a much diminished blood supply which greatly increases the damage and which, alone, would be productive of like damage. When *stimulation in any form* (massage, galvanism or what not) is applied the already overworked muscle is simply *totally exhausted* for a time and fibrillation ceases during that time to resume when the muscle, by rest, has regained some measure of reactivity. The continuous overwork and undernourishment—both caused by severance of nerve—results in a condition of fibrosis in muscles. Thus it is plain that *any* stimulant treatment is contraindicated during the fibrillation period which starts as soon as the summation of stimulation reaches the stage of irritation (three, four or five days after the injury) and lasts until regeneration has taken place or until death of the muscle fibers or progressive fibrosis halts the power to contract under the continual irritation. Applying stimulation during this period is simply adding insult to injury. The neurosurgeon, knowing the results of these researches, is prone to refuse to allow the physiotherapist to touch the case until after six weeks have elapsed because of his belief that *all electrical*

treatment is stimulating. If this assumption were true then this negative treatment would at least be better than the stimulant positive treatment but it *most positively is not true* and the practice of many prominent surgeons in refusing to allow physiotherapy to be started until after a lapse of six weeks from date of injury or suture is exactly analogous to a fire chief who would forbid the use of water or any chemical extinguisher upon a fire until after the building had collapsed and lay smouldering. Without such treatment six weeks, or even four weeks, after a nerve has been severed nearly all the damage that *will ever occur has occurred* or has progressed to a point where future changes can hardly be prevented. The difference between war nerve injuries and peace nerve injuries is all in favor of the latter. Often in war the nerve injury case could not be moved back from the front and transported varying distances to a hospital equipped to carry on physiotherapy until after the lapse of weeks or months. In civil hospitals the injury can be started on proper treatment at once, provided the hospital is modern.

At a convention of physicians held in our clinic the neurosurgeons attempted to joke me by saying that, at first, they only allowed physiotherapy to be administered after six weeks but that the reconstruction officer was so persistent that they cut the time to four weeks but still he was not satisfied and that later they had cut the time to three weeks, to two weeks, to one week and finally to two days "but, do you know, Sampson is not yet satisfied. He wants these cases *before they come out from under the anesthetic.*"

The best time to prevent grave danger from fire is to begin extinguishing it *the moment it starts,* and exactly the same thing holds in nerve injuries. The moment a nerve is severed or injured beyond natural repair—whether by cutting, tearing, crushing or what not—a certain train of events is set into motion. Wallerian degeneration of all that part of the nerve distal to the point of severance is inevitable. This degeneration cannot be prevented by any known means and the treatment recommended here is not to try to prevent such degeneration but to prevent or at least very greatly to minimize the accompanying vasomotor, atrophic, sclerotic or fibrous changes in all the structures below

the seat of injury, and to hasten—markedly—regeneration. In all cases these changes, unless prevented, will result in permanent disability or at least in the necessity for months and years of intensive treatments before such disability can be overcome and function restored. Wounds to the nerves not resulting in complete severance oftentimes cause more intense fibrosis and other degenerative changes than complete severance. In these changes the whole motor mechanism—bones, joints, muscles, tendons, aponeuroses, synovial sheaths, the nerve sheath itself, the covering skin and its appendages—all are more or less affected either by direct trophic or fibrous changes or by adhesion to or compression from neighboring structures. The process of scle-

Fig. 68.—Ischemic paralysis following a too tight application of a Bier's hyperemia bandage for a septic condition of the forearm. These cases require more and harder treatment before function can be restored than those of almost any other character.

rosis of joints, fibrosis of muscles, contractions or massive adhesions may progress to such a point that, after the characteristic pose or griffe has "set" a finger or toe may be broken before it can be bent. The degree of fibrosis in some of these cases is only exceeded by that in ischemic paralysis. In fact, I think that the worst damage in these cases *is* caused by an ischemia, the arterioles and periarterial plexuses sharing in the general irritation plainly evident in the whole area.

In any event, we know that certain changes impend. We know that, let alone, the muscles at first will be overirritable and later will lose all power to respond to motor point irritation;

that they will atrophy and fibrose; that all the other motor mechanism will share in that human rust process, fibrosis, and in the destruction from the ischemia to such a degree as to render them unable to resume function when the nerve regenerates or able to resume only partially or to resume after months of effort directed to *removing* a condition that should not have been allowed to form. We know that this rust process which, unchecked, will literally lock up the motor mechanism to a point where a mechanic would call it ''frozen'' starts at the time of the injury. The time, then, to start preventive treatment is as soon as possible after the injury has been received. The indications for the first stage treatment are very plain. Something to prevent or minimize fibrillation; something to allay irritation; something to convert an ischemia into a hyperemia *without producing stimulation in the area;* something to prevent, or remove as it forms, fibrosis, with fibrous ankylosis and adhesions compressing the nerve sheath down which regeneration must progress to a point that may stop regeneration at that level, etc. Have we any such remedy or remedies?

If we had been permitted to create a remedy to fit the indications we could scarcely have improved upon conversive heat. The arterial hyperemia it produces is the antidote to atrophy —the two cannot exist together. The ischemia instantly disappears. The intensely sedative effect of conversive heat cannot easier be proved than by its use in this very condition after regeneration has taken place and the muscle has begun to respond to irritation of its motor point. On a case at this stage make a test of the amount of irritation necessary to provoke a contraction and record the amount. This is best done with a Lewis Jones muscle testing condenser set which stores a definite amount of current at a definite voltage in each metered condenser section and which thus permits of exact measurement of the *amount* of current necessary to produce the irritation required to secure a response from the muscle. Give a forty minute, sedative technic, diathermia treatment through this whole area and repeat the test after the treatment and daily for some three weeks. It will be found that after the treatment several times the amount of

current (irritation) will have to be applied to secure the same response and that this obtunding effect upon the irritability of the muscle will last for from two to three weeks or more. This same property of conversive heat is well illustrated in its use precedent to forcible manipulation for breaking up fibrous ankyloses. Not only has it a solvent effect but the relaxation and sedation produced permit of the use of much more force with much less pain than would be the case were manipulation attempted without its use. Adhesions, impossible of separation before diathermia, often come apart under manipulation or stretching after conversive heat has been applied. Neurosurgeons have called our attention to the distinctly easier process of separating nerve trunks from surrounding adhesions in areas that have been diathermized regularly for some time previous to the operation. So marked was this difference that in many of these cases the nerve could be freed by blunt dissection with the scalpel handle. Another thing noted and objected to by the neurosurgeon was that capillary oozing was very hard to control in these cases and this led to rule of diathermizing these cases some weeks before the operation and ceasing all diathermia treatments some ten days or two weeks previous to the operation. The distinctly anti "itis" properties possessed by conversive heat make it invaluable in the treatment of any form of neuritis but distinctly so in preventing that awful complication of some of these mixed bone infection, nerve injury cases: an ascending neuritis of the proximal or central end of the nerve. Causalgias would be conspicuous by their total absence if all cases were treated promptly after the injury by conversive heat. The preventive effects are as effective whether irritation of vascular nerves or of periarterial plexuses operates as a cause. Conversive heat in these nerve cases is so many times more effective than any other form of heat that there is no room for comparison, but of all places, this demands a real sedative technic.

The first stage (first four to six weeks) treatment then is diathermia applied with the sedative technic and applied daily or oftener. Here we are going to repeat a caution given under diathermia. *Never, in any circumstances,* administer a diathermia treatment

to a limb encased in a *rigid cast or splint* as there is a real danger of producing a condition worse, even, than a nerve injury—ischemic paralysis. If the limb *must*, on account of concomitant bone injury or disease, be left in a cast, then split the cast along the sides and just before the diathermia treatment remove the rigid cloth bandages and substitute a few turns of woven elastic bandage around the cast so as to allow for the expansion of the limb and not compress the blood vessels. In addition to the daily diathermia an ionizing dosage of x-ray (5 ma. min., 5 inch back-up spark, 1 mm. aluminum filter—8 inch target-skin distance) should be given over the injury taking in some inches of the central end of the nerve and, by treating successive open areas (all others covered with crookes metal or lead) follow the limb to its extremity and the whole area involved treated once a week with this small x-ray dose.

All and more than could be accomplished by daily massage is thus accomplished *without stimulation* or danger of the damage that would ensue from even the slightest overenthusiastic massage treatment. These muscles are extremely fragile and if massage is used, must be handled with the greatest of care and gentleness. Let us analyze the movements of massage and see just what is expected from each in this condition and then see how much better it is performed under conversive heat.

Effleurage, Stroking or Friction

Lightly performed this cannot hope to do more than act as a very *mild* sedative and—it is said—promote metabolism of deeper structures by reflex action. Diathermia is infinitely more sedative and does not depend upon a more or less hypothetical reflex to promote deep metabolism. The first stage of any local repair is a hyperemia and an active arterial hyperemia such as is provided by conversive heat is not to be compared to that produced by *any* other means. The heat activates all metabolistic processes as well as furnishing more active arterial blood to carry it on. *Deep stroking* is for the purpose of emptying lymphatics and veins and to generate a certain slight amount of frictional heat but is stimulating in character. Diathermia not

only opens up the exits but floods the inlets and as for the heat there is no comparison either as to quantity, evenness of distribution or metabolistic effects, and it is *decidedly* sedative in character.

Pétrissage, Pinching, Kneading

These movements are used to improve nutrition by emptying the structures under treatment of blood and lymph, break up fibrosis or stretch adhesions. Assuming that massage is used in these paralytic conditions it is very much limited for the very fragile muscles will not survive any bruising, stretching, etc. Only the gentlest of movements can be used (and no great degree of stretching) and these are only partly efficient in remedying the evils aimed at on account of this limitation. Under conversive heat not only is local metabolism greater, but the blood carrying heat out of the areas under treatment to internal organs stimulates general metabolic activity and, as conversive heat is the best solvent as well as preventive of fibrosis that we have, fibrosis and adhesions are prevented or minimized to a point easily handled as the parts regain their ability to stand heavy work.

Tapotement, Hacking

From its very nature tapotement is contraindicated until recovery has progressed to practical completion so need not be considered here. So it can be seen that the use of conversive heat in the first few weeks has everything to recommend it. When it is stopped at the end of the fifth or sixth week (when regeneration of the nerve may be expected to set in) it is not stopped because its use further is contraindicated, but because the period of greatest danger is now over and a different form of current can now pick up and carry on *without masking* the *diagnostic tests* the surgeon must make to gauge progress and which he could not make with any degree of accuracy if the administration of conversive heat were continued and because stimulant treatment is no longer contraindicated. These tests depend upon the response of muscle to motor point stimulation and

the irritability of the muscle is so obtunded under diathermia treatments that the readings are thrown out of all proportion to what they would be if the part were not being diathermized. Therefore we cease giving diathermia and start on the slow reversing galvanic sinusoidal.

The hand or foot is placed in a warm salt water bath with one cord of the sinusoidal in it and the other electrode of the circuit is applied to the cervical and upper dorsal spine in the case of a hand or to the lumbar spine for a foot. We use the slowly reversing galvanic sinusoidal here for the reason that we want all of the metabolism stimulating effects of the galvanic current without any of its polarity effects which we would secure did we use the straight galvanic current. The uninjured hand or foot is first placed into the salt solution, the rotor set so as to give one or two waves a second and the control rheostat handle advanced slowly until tolerance of patient or signs of contractions of muscles are noted. This point on the control rheostat is marked or noted, the rheostat turned slowly back to zero and the injured limb placed in the salt solution. The control rheostat is then slowly advanced as before but is stopped about one-fourth to one-third of the current strength reached on the healthy side. For instance, if sixty volts on the scale is reached on the uninjured side then you would stop at 15 or 20 volts on the injured side. If no scale is provided on the rheostat then note the distance the handle or knob traveled for the healthy limb and advance it only about one-fourth as far for the injured limb. As this amount of current will not cause attempted contractions in the paralytic muscles it may be given for ten or fifteen minutes each day for its metabolism stimulant effect to the whole limb.

Then the treatment should be stopped and a very little individual muscle stimulation administered to each of the paralytic muscles. To do this, discard the salt water and spinal electrodes and attach a pair of small electrodes one to each cord. Have both their covering (gauze squares tied or clipped over the metal by rubbers or small sponge electrodes) and the skin well moistened. To keep them from drying out too rapidly a lather

of soap may be used and renewed occasionally by dipping into a small dish of lather or rubbing over a piece of soap in water. As the muscle at this point will not respond to motor point stimulation it is useless to attempt to exercise them by applying the current over motor points. Slow the motor down to a very low speed, so that not more than one complete revolution of the brushes (one complete cycle) per second is being delivered and turn the rheostat up until when one electrode is placed at one end of the muscle and the other electrode at the other end a weak contraction takes place upon each negative phase of the cycle. If the strength is regulated properly this longitudinal excitation of the muscle will produce a slight contraction at each negative phase, but no visible effect as the positive phase goes through the muscle. Give the muscle one negative phase, lift one electrode to stop passing of current and hold it off the muscle for about three times as long as the period of the contraction. In other words, one part of current and three parts of rest. Then put it back and give another negative phase and again rest the muscle by raising the electrode and stopping passage of current. Give each muscle about three single contractions divided into one part work and three parts rest and then go to the next muscle and treat it the same way and so on. This is enough work to require the very weak muscle to perform in one day. Overwork at this time is the worst thing that can happen to the muscle and as between no work and overwork no work at all is very much preferable.

When regeneration has progressed down the nerve the reaction of regeneration will appear—the muscles progressively regain their ability to respond to irritation of their motor points. This reaction of regeneration manifests itself upon tests of stimulation of the motor points which tests should be made at least twice a week as regeneration progresses. The muscular response at first may be very weak, irregular or vermicular but once it appears the muscle should be exercised *by motor point stimulation* (one electrode over spine, small motor point electrode over motor point) from that time on. The reaction of regeneration appears in reverse order to the reaction of degeneration.

The first thing to lose its power to produce contractions of the muscle through motor point stimulation is the low voltage faradic (Bristow coil). As the reaction of degeneration progresses the high voltage faradic (Chloride of silver dry cell and other fine wire wound faradic coils) fails, then interrupted positive galvanic and lastly the interrupted negative galvanic.

After regeneration of the nerve has taken place the first thing to elicit a response (the response is always weak at first and will be missed if the tester is looking for a contraction vigorous enough to throw a coin off the muscle—it may only be enough of a response to produce a flicker of the tendon or a very weak, wormlike wave of contraction) from motor point stimulation is the interrupted negative galvanic. Next will appear response to positive galvanic, then to the high voltage faradic and lastly to the Bristow coil or low voltage faradic. The limb being tested should always be positioned at complete rest and the test made in a good clear light where the slightest response may be noted. For fine diagnostic testing I still prefer the galvanic current with the simple interrupter handle electrode but after a positive response is obtained then the Lewis Jones condenser muscle testing set is almost invaluable in furnishing a perfectly metered gauge of progress. Tests at intervals of a week or ten days with it furnish invaluable information as to rate of increase of tone, the muscle responding to shorter and shorter stimuli as tone increases. If the charging voltage is always kept at the same figure (it should be made a rule of practice to set the charging voltage *always* at the same figure for routine testing as otherwise exact comparisons are impossible) then the number of condenser sections (capacity—time of discharge) is the only variable factor. The time it takes a given capacity condenser to discharge is easiest calculated at an even one hundred volts and there are no objections to this voltage figure so that we do all our testing with the control rheostat set so as to give a charging voltage of 100 volts. The resistance of the skin, if properly lowered by liberal moisture, is near enough alike in various localities to be considered a constant and is so considered in practice. The time required for the discharge of one or more sections of the

condenser varies from about $\frac{1}{30,000}$ of a second for a section having .01 microfarad (one one-hundredth of a microfarad—a microfarad is one-millionth of a farad) to about $\frac{1}{200}$ second for a full farad. Normal muscle where its motor point is superficial will often respond to the discharge of .01 microfarad through its motor point and most of them except some of the deepest ones will respond to .02 microfarad. The further a muscle goes from normal, the more condenser capacity (with its slower discharge time) will be required to produce a response to stimulation at the motor point from which it can be said that the weaker the muscle the slower must be the impulse to its motor point to cause a contraction in the muscle.

When the Lewis Jones condenser muscle testing outfit (or a slight modification of it) was first introduced, we stated it as our belief that it would not replace galvanism and faradism for the finer diagnostic testing but that it would fill a crying need for some standardized method of gauging progress in cases already diagnosed and this is what has happened both in this country and abroad in the larger clinics.

To recapitulate up to this point: Immediately after a severe nerve injury (surgical procedures having been carried out if indicated) conversive heat in the form of sedative diathermia is applied to the whole affected area daily taking in some inches of the central end of the nerve and an ionizing dose of x-ray sprayed into the same area once only each week. At the end of four or five weeks when degeneration and its irritative syndrome has practically completed then diathermia is stopped and weak slow galvanic sinusoidal baths are given daily in its stead and the weak muscles given a very little and judiciously applied strengthening exercise utilizing the longitudinal reaction until tests show that regeneration has reestablished the connection between nerve and muscle through its motor point when all other treatment except the ionizing dose of x-ray once a week is stopped and a very rigid system of strengthening exercises applied through the motor points is started. It is well at this time to do cautious manipulation or mobilization movements of all the joints daily, care being taken that only one or two such

motions of each joint are made each day and that they are not of such extent as to put damaging stretches or stresses upon the paralytic muscles else they will do more harm than good.

If the section on the comparison of the slow galvanic sinusoidal and interrupted galvanic is studied the reasons for the technic here given will be explained and will not be repeated here.

The technic for exercising and strengthening the muscles as soon as reaction of regeneration shows that it can successfully be used is as follows: With one electrode on the spine and the other a motor point electrode go over the uninjured side area corresponding to the paralytic area and locate each motor point by motor point testing. With a colored pencil or ink mark each one as located. With a millimeter rule using landmarks as bases measure off the approximate location of the corresponding motor point on the injured side. There is sometimes an apparent displacement of the motor point towards the tendon on a paralytic muscle but this tendency is absent or only slightly apparent on muscles properly treated from the start. When the motor point has been located definitely by testing for it, mark it so that it will not have to be re-located at subsequent treatments. Then give each muscle—separately of course—three contractive impulses through its motor point on the first day of its response, using the slow galvanic sinusoidal with a slow sine wave delivery at first and giving the muscle three periods of rest between each of the three contractions. No attempt should be made to make these contractions snappy or vigorous by increasing the current beyond that necessary to provoke a mild contraction. On the next day give the motor point four separate stimuli in the same manner and the next day give each muscle five contractions, the next day six, next seven, eight, nine and up to the day when, by advancing the muscle work one contraction each day, ten contractions per day per muscle are being given. Then make a record test of each motor point and compare it with the original record test when contractions were first discovered following motor point stimulation. At the first test the record should show, in addition to the fact that a posi-

tive reaction was found and the current necessary to produce it, just what the character of that reaction was—whether very feeble and slow, vermicular, fairly strong and slow or rapid or fairly prompt, approaching normal, apparently normal, etc. Thus successive tests at weekly or ten day intervals showing some such record as the following would denote regular and satisfactory gain in tone:

Date	1st	test.	Faintly positive—slow	.10	microfarad
"	2nd	"	Slow but stronger	.08	"
"	3rd	"	Same	.06	"
"	4th	"	Stronger and fairly prompt	.05	"
"	5th	"	Prompt—much stronger	.04	"

If after a series of tests showing steady improvement a succeeding test shows a distinct loss, then something is wrong. Do not be too ready to blame the one giving the treatments. It may not be overtreatment. A sudden alcohol debauch on the part of the patient will cause some very discomforting things to appear on the test sheet. This is so true that it has positive diagnostic value in these cases, where long enforced idleness, well meaning friends, and a thirst made such occurrences not impossible. Care should be taken that on test days the tests are made before the muscles have been compelled to do their daily stint of work and the patient should be instructed that because a *little* work is good for the muscle he must by no means assume that a *lot of work* is better and do a lot of manipulations on his injured limb himself. Progress in the best of these cases is necessarily slow and the patient should receive enough moral support during his course of treatment to keep him contented with the slow progress he is making, otherwise he is prone to "jump the reservation."

If the test taken when the daily stint of work for any given muscle has reached ten contractions does not show satisfactory gain in tone, then the series should be repeated, dropping back to three contractions a day and increasing one each day up to ten, until such test does show satisfactory progress. If the gain in tone shows *rapid* progress, then the amount of rest between

each contraction may be cut down to one part work and two parts rest and later, to one part work and one part rest. Continuous work with no rest intervals should *never* be given these weak muscles. At these weekly tests one or more of the first muscles to respond to motor point stimulation should be tested with a high voltage faradic current and the date of response noted on the record sheet. When high voltage faradic produces a response it is only a short time until the low voltage faradic or Bristow coil will also produce a response and from that time on the surges from a Bristow coil may be substituted for the sinusoidal. The slow rate of interruption, the low voltage and the greater amperage of the Bristow coil makes surges from that instrument more effective and less painful than any other faradic current when the stage of regeneration has been reached that permits of its use.

When the stage of ten daily contractions has been reached for any given muscle and tests show steady improvement, reeducative exercises designed to show and use voluntary motion should be instituted and added to his daily treatment or they may be made entirely to take the place of the progressive contractions—care being taken to increase them about in the same ratio as before—not over one or two added contractions daily. These exercises are at first carried out by the assistance of the slow galvanic sinusoidal and gradually, as improvement progresses, more and more by voluntary movements, until they finally are entirely voluntary the first half of treatment and Bristow coil exercises the second half.

The muscles, in the order of their come back are reeducated somewhat as follows: One electrode on the spine, the other the usual motor point electrode. The patient is shown that the muscle can and does contract under the slow sinusoidal to the motor point and is now told (the truth) that voluntary movement is not only much better for the muscle but that the nerve and muscle must be trained by use to work together before function will re-appear. Instead of a plain motor point electrode, an interrupter handle motor point electrode is substituted. The handle of this electrode is so held in the hand of the operator

that the interrupter spring is concealed from the patient's view so that he cannot tell whether it is depressed to make contact or not. The limb is positioned in a perfectly relaxed pose, the sinusoidal machine started, the control lever advanced to the point usually used in his daily treatments, the skin and electrode thoroughly soaped and he is told that at the count of three contact will be made and the muscle caused to contract. He is told to concentrate his mind upon this particular muscle and movement and try to aid the contraction by voluntary motion. The operator slowly counts three and on the count of three places the electrode on the motor point *with the spring depressed* so as to pass current. The muscle contracts. This is repeated two or three times with current passing each time. Then, on the third or fourth trial the electrode is placed upon the motor point as the usual three is counted but this time the contact *is not made* in the handle and the muscle is watched to see whether any contraction results. Of course if it does it is purely voluntary and the date of such first voluntary movement should be entered upon the record sheet. This sequence should be repeated until the daily number of contractions has been reached. The terrific synergic contractions of all the other muscles, so evident when the patient is told to attempt to produce voluntary motion unaided, is not so much in evidence—in many cases is almost absent—and as a result voluntary motion is easier and appears somewhat sooner under this method.

When the muscles respond to Bristow their development from that time on is rapid and they gain ability to stand added work very fast. When voluntary motion has appeared and the muscles have gained a state of tone warranting it, occupational therapy should be added and carefully supervised to prevent gross overwork. Various appliances—Tait Mackenzie apparatus, Zander, etc.—can now be used to increase function. We had an entire ward building full of these appliances and made constant use of them in these and other cases, but in nerve injury cases they are a latter stage treatment. These appliances, games, and the various departments such as the carpenter shop, toy shop, looms, presses, etc., of a well equipped and run occupational therapy

department are invaluable adjuncts in these and many other cases.

Where a case of nerve injury comes in several months or a year or more after the injury, the treatment can only be directed to removing as much of the damage as possible, breaking up and removing the fibrosis, etc., restoring mobility to joints, muscles, tendons and preparing the case for indicated surgical procedures such as suture, graft, neurolysis, etc. Conversive heat is again the basic remedy and forcible manipulation is used to mobilize. If operative procedures can start regeneration after an intensive preparative physiotherapy course then the postoperative treatment is the same as for recent injuries with such modifications as the more advanced pathology dictates.

To sum up the treatment of recent injuries: First four or five weeks, daily sedative diathermia and a once a week ionizing x-ray dose. Gentle, limited movements of joints. Substitution of weak, slow galvanic sinusoidal baths and selective exercise of muscles by same current using the longitudinal reactions of the muscles, interval motor point testing, and motor point stimulation when regeneration has progressed far enough, reeducative exercises upon gain of tone, Bristow coil stimulation later and mechanotherapy with appliances or occupational therapy or both still later, gradual increase in joint motion range as tone of muscles warrants, etc.

No mention has been made of surgical indications, operations, diagnostic and differential diagnostic tests (except just enough to gauge progress) splints, braces and orthopedic appliances because these things are thoroughly covered in such works as Tinel's.

Some of the complications should be considered. If bone injury or osteomyelitis complicates, then, drainage being established, sedative diathermia, local and *general* ultraviolet light to damp out the process. We have seen many exceedingly bad cases of osteomyelitis which had resisted repeated operations, months of irrigations, etc., clear up in a comparatively short time when placed upon this treatment. To our mind the general ultraviolet applications are even more beneficial than the

local although the local should be used in every accessible case. For trophic or pressure ulcers nothing is so good as the ultraviolet applied as in acute x-ray burn. Diathermia through these limbs has a tendency to hasten reparative processes in these stubborn ulcers also and does not interfere with the ultraviolet, in fact aids it. In the absence of diathermia some other heat application—whirlpool baths, 1500 watt lamp, etc.—will aid.

Causalgias

The terribly painful causalgias of some of these nerve injury cases gave no end of trouble to every one having to do with the case. Some of these cases presented a truly pitiable state. Cages had to be built to keep bedclothes or drafts from touching the skin of the affected area. The patient would scream in agony upon the slightest move of any one to touch the limb or its support. Any unusual sound such as the sudden popping of a steam pipe, the slam of a door, any mental emotion, etc., was sufficient to start one of the intense paroxysmal pain attacks. On account of the impossibility of handling the part, treatment was difficult. We used ionizing x-ray over the affected nerve end area and over the spine and secured total relief in a very few cases and alleviation in a few more. We used the static effluve with temporary relief in a few cases, but the pain recurred in a few minutes or a few hours. We used the whirlpool bath with good results in some cases—were even able to handle the limb in a few cases after three or four treatments. We used conversive and convective heat with little or no benefit in most cases. We used the positive galvanic current and nearly every case became worse after the initial sedative effect wore off in an hour or so. We used combinations of remedies—even sedative ultraviolet. Finally, both because we were becoming desperate and had tried everything else and because the indicated polarity of the galvanic (positive) instead of relieving had aggravated, we decided to try the negative pole. I shall never forget the young riot that greeted my announced intention of trying the negative pole. The aides protested so strongly against doing anything so contrary to the rule as applying an irritant current

to these hypersensitive areas that it took a special meeting and finally the laying down of the law to get them to do it. Finally one of them volunteered to make the trial "if you order it" and it was made. Only a very weak current was used—the extremity of the limb gently lowered into warm salt water, the negative pole cord into the water, the positive pole at the most distal point on the spine and a current of from one to three or four milliamperes gently started and run for thirty minutes. Over 90 per cent of the cases so treated improved rapidly under the treatment and from that time on one of the terrors of the clinic ceased, almost, to exist. This result was confirmed in many other clinics. Empiricism, if you please, but that was not what the patients called it. Of course the explanation when puzzled out later was simple. The pain was caused by too little blood in the part. The astringent and dehydrating effect of the positive pole was greater than its temporary anodyne effects and the vasodilating effects of the negative current (in such small dosage) overbalanced its irritant effects.

Ascending Neuritis on Central End of Injured Nerve

Treatment same as for neuritis in any other locality—diathermia, x-ray—static—plus redoubled efforts to lower virulency of infection (usually bone) area by intensive diathermia, local and general ultraviolet light, etc.

CHAPTER XVIII

MASSAGE

Massage is a form of mechanotherapy. In some of its forms it is one of the oldest of therapeutic procedures and the fact that it has survived is proof of its helpfulness in many conditions. When I speak of massage, I mean real massage—not the variety administered by a bath house husky who seems to think that unless his ministrations can be heard beyond the confines of the block his "patient" is not receiving his money's worth. This does not mean that a big man or woman is necessarily a rough operator. One of the most sedative massage treatments that I have ever had given me was done by a man who was a perfect physical giant, over six feet in height and weighing 227 pounds, while the most irritant one I have ever suffered was given by a little undersized, anemic woman when I asked for a sedative massage. The violent assault and battery of the husky who assays massage without understanding its theory or technic may be endured without permanent damage by the type of able bodied man who prefers to purchase his exercise by proxy, but physicians should never make the mistake of submitting diseased or injured patients to any such operator. The best way to determine the efficiency of a given operator is to have him or her give you a treatment. If you really have a sore muscle or group of muscles or a sprain so much the better, but you can gauge the technic better this way than any other. It is a method I have used many times to check up a masseur or masseuse after patients had complained of rough work which was not evident from watching the work being done upon some one else. A proper technic is just as absolutely necessary for success in massage as in the administration of any other physical remedy.

It is claimed for massage that it promotes metabolism, maintains nutrition, restores strength to weak muscles, prevents adhesions and helps break them up if already formed, breaks up

fibrosis, hastens repair after injury, prevents and helps restore lost function in muscles and joints and renders voluntary motion in diseased or injured parts easier.

All these claims have more or less justification except the one of restoring strength to weak muscles. Attempt is made to support this claim by quoting the admitted fact that an athlete in an almost totally exhausted state can, by a few minutes'

Fig. 69.—Corner of general massage section.

vigorous massage, be placed in condition to undergo sustained effort which without the massage he could not have attempted. This is not a proof, for the muscles in question were not *weak*. They were more or less temporarily inhibited or paralyzed from the presence of a fatigue toxin (sarco-lactic acid and other fatigue products) which the massage removed from the muscles themselves for oxidation or disposal in the eliminatory organs to which the circulation carries them. The muscles were vigorous a few minutes before and are still capable of their normal

effort as soon as the restraining shackles are removed. Striking the fetters off a weak horse will not make him strong, but striking them from a strong horse will again render him capable of performing his work. There is only one way to strengthen a weak muscle and that is to use something that will *contract* every fiber of the muscle, use it regularly, and not overdo it. This technic is fully explained in the chapter upon nerve injuries.

Massage (including manipulation) fills an important niche in any physical clinic and I would not attempt to do physiotherapy without it, but just as the ox cart was once the very best means of travel and still is a very sure means, although not so much used as formerly, it is no longer the very best way of accomplishing many of the things formerly given over to it almost exclusively. When it was the best *known* remedy for a given condition it was good therapy to make it the remedy of choice, but when advancement in knowledge of physics, biophysical or chemical reactions, appliances and technics for their proper use in producing them showed a better means of producing the desired reactions then it ceased to be good therapy to use massage in place of the better procedure. I am moved to make these observations not from any desire to detract from proper massage, but because of the fact that in the minds of a great part of the profession there is a fixed obscession that massage and hydrotherapy are about all there is of physiotherapy and therefore if massage will not do the thing they desire to have done that thing is not a condition for the physiotherapist to handle. Most of the men who, because of their prejudice, will bite themselves and run in circles if *electricity* is mentioned to them (they have an *extremely nebulous* idea of what the term electrotherapy implies but they emphatically *know* that it is bad) will go to the other extreme and make claims for *massage and hydrotherapy* that are just as ridiculous as the sweeping claims made for electrotherapy by certain electrotherapists equally well grounded in applied physics. Physics and its application to disease and disability (applied physics) seems to be the one thing in therapy that both of these classes have never studied as even a superficial study of the basic laws would prevent either of them from

making any such dogmatic statements. The proper choosing of a remedy is just as much a part of the correct technic as the proper application of the remedy after it has been chosen. Massage, then, occupies no such major position in the physiotherapy field as some of its proponents claim, and, as usual, it is entitled to more credit than is conceded to it by those refusing to admit that it has any more than a slight value in a few cases. In truth its chief value is as an *adjunct* remedy in the office or clinic

Fig. 70.—Corner of general massage section.

where physical equipment is available and it is entitled to rank as a major remedy only in emergencies by virtue of the fact that one skilled in its use always has the apparatus for giving it with him and sometimes a prompt treatment with massage is better than a delayed treatment (which for many reasons may never be given) with some more efficient physical remedy.

Some practices of massage give as many as seven different movements, but three main movements will cover. The others

are modifications of one of these three. These three are *effleurage,* or stroking; *pétrissage,* or kneading, grasping, compressing, or pinching, and *tapotement,* or striking, hacking or slapping.

Massage is local or general in character according to whether a single extremity, joint or part is to be worked out for some local injury or whether the whole body is to be gone over systematically as in injuries or convalescence requiring long stays in house or bed, etc.

In general massage it is absolutely necessary to have the patient lying at rest upon a nonspringy table of proper height. For the average height man or woman operator a table of twenty-eight or thirty inches in height, of about the same width and six feet or more in length is preferable. This can be covered with a thin mattress or many folds of comforters or blankets and covered with a clean sheet. A very handy addition to this massage plinth (which may well be made of hard and soft pine) is a shelf running the length of the table but not extending clear out to the side lines (say 15 inches wide) where it would interfere with the operator's feet and placed a foot or more above the floor. This will be found a convenient place to lay pillows, bandages, extra clean linen, pans, etc., and will save many steps in the course of a day. General massage can be given in an ordinary bed if the exigencies of the case demand, but is a very tiresome procedure to the one having to give the massage. For local massage the part should be placed completely relaxed and at rest. In our clinic it was necessary to give hand and arm cases massage with the patient sitting alongside a small table and the arm resting upon it. This will answer where the arm can be placed in a perfectly relaxed position.

Some form of heat such as "baking" (twenty or thirty minutes' exposure to radiant light and heat), whirlpool bath or diathermia usually precedes the massage. Where the latter is properly used manipulation is about the only procedure needed to complete the treatment.

The question of the use of a lubricant such as vaseline, petroleum oils, olive oil, etc., comes up. After trying extensively all these things and comparing them with friction reducing powders

such as boracic acid and talc we finally adopted the use of talcum powder where any large surface was to be covered. Many times even this was not used. Talcum powder (which can be obtained cheaply in five pound box cartons) is easily applied, easily removed and in general is not so messy as the oils. Where a particularly adherent scar is to be worked out the use of vaseline is permitted.

When a limb is to be massaged the clothing should be re-

Fig. 71.—Corner male massage section.

moved, as if it is turned or rolled up the constriction of the veins and lymphatics seriously interferes with the proper emptying of the area under treatment. If the area is not emptied then practically all the value of the treatment is lost. A tough sack of marbles tied over the open end of a pipe may be emptied through the pipe by massage or manipulation of the sack if there is no barrier to the passage of the marbles at the distal end of the pipe. If there is such barrier then it must be removed be-

fore the operation can be done successfully. The start, then, of a massage should always be at the proximal end of a limb and the veins and lymphatics worked out there first, gradually extending the operations a few inches at a time until the whole limb is included. If the whole body is to be massaged the parts not under treatment should be kept covered, successive parts being uncovered and treated parts covered as the treatment progresses.

Effleurage or stroking is the first movement carried out. This is done in one of several ways and when lightly done is sedative in character. It can be done with the palmar surface of a thumb or one or all of the fingers or with the whole palmar surface of the hand, or if preferred and care is used, with the ulnar aspect of the hand or the dorsal aspect of the fingers. The stroke should always start in the direction of the flow of veins and lymph, should be continuous from its start to the point where it is no longer possible to follow up these afferent channels, pressure (never very heavy) removed and the hand quickly returned to the starting place or to a point a few inches beyond after a few strokes without raising the hand entirely off the limb. Thus the stroke is continuous. Up with light pressure and back with almost no pressure and repeat. The procedure is sedative and relaxant in character when lightly and slowly done and stimulative when rapidly done, especially if a little more force is used. A necessary precedent to all massage where no preliminary heat treatment has been used, less of it suffices if good radiant light and heat or whirlpool has been used and it is superfluous if *conversive* heat has been applied.

After the area has been prepared by one of the procedures mentioned the next step in the massage is pétrissage. The purpose of the manipulation is to empty the deeper structures, to free forming adhesions, to help break up fibrosis, to stretch muscles, free tendons, etc. The movement should be gauged in intensity, trauma should never be administered and the general purpose of the manipulation constantly borne in mind. The successive movements by which the structures in an area are picked up, alternately compressed and relaxed with the general push

on the fluid contents towards the big veins or lymphatics without intermissions which would permit of a regurgitation of the fluids to the area just covered, and the releasing of tension upon one skin area as another is entered without exerting a traumatizing force upon skin and hair, is an accomplishment that can only be learned under competent personal instruction. It cannot properly be taught in a book as it must be seen and practiced before it can be mastered. That does not mean that one knowing

Fig. 72.—Corner of general massage section.

the theory and the various movements but more or less unpracticed in them should refuse to try them in an emergency, but that one should not be satisfied to do a thing wrong if it is possible to learn to do it right. Have good operators demonstrate the movements upon you repeatedly and note the technic. Then try it upon them and have them criticize your technic. One day of this instruction will teach you more than you could learn from the best book upon the subject in weeks of hard study.

Undue trauma—especially tension upon hairs—may result in sequelae that will make subsequent treatments impossible (dermatitis, myositis, neuritis, folliculitis, etc.). The tendency of the beginner is to be a little too vigorous and too long and so to overdose the areas. In our clinics an operator detailed to do a general massage averaged about forty-five minutes for the task but a particularly difficult case might require an hour. From

Fig. 73.—Massage and manipulation. Patient on left receiving radiant light and heat from an eight bulb applicator preparatory for massage. Patient in foreground receiving massage and manipulation of both arms for a double nerve injury. Patient on right has had a diathermia, is now receiving a forcible manipulation to break up a fibrosis from long casting for an osteomyelitic process, and will receive a static condenser discharge treatment at the end of his forcible manipulation to remove the condition of acute strain resulting from the manipulations which otherwise would render the limb so sore that all treatment would have to be suspended for several days and the benefits of the manipulation lost. This combination with the addition of ionizing doses of a soft x-ray every five days will, if pushed and persisted in, often result in restoring motility and function to joints that could not possibly be mobilized by other procedures.

five to fifteen minutes was average time for a single joint or an extremity, but it should be remembered that *all* of our cases received some form of heat application before the massage. A

delicate touch is a thing to be desired and cultivated. Probably the most sedative touch I ever experienced was in a treatment by a blind masseur. It is reported that the Japanese specialize in training the blind to this work, and many papers have been written showing the proficiency of the blind at this vocation.

Like effleurage, pétrissage may be carried out with the finger tips, the apposed thumb and fingers or even the two hands. If the two hands are used together both sides of the limb may be

Fig. 74.—Massage in arm and shoulder injuries.

treated at the same time and alternate advancement of first one hand and then the other may be used or a rotary movement imparted to the limb, the hands gradually approaching the trunk. Around joints the motions are modified to suit the configuration and circular friction with the palm, thenar eminences, or finger tips is more used.

After the area has been pétrissaged if it is desired to administer tapotement it can be done in a number of ways. It is

usually administered over an area with the muscles in the area in a state of contraction. So administered it is the most stimulating of the movements. This is the movement that in careless or clumsy hands is more liable to do damage. It is administered by delivering a succession of short, rapid chops or strokes to the muscles—across their long axis—using the ulnar edge of the fingers, or the hand, the backs of the fingers or in some cases the cupped palm. For superficial effects the fingers are used. When deeper effects are desired the ulnar edge of the hand is used. In any case the blows are rapidly delivered, snappy, regular wrist chopping motions. *Never* should heavy *full arm* blows or *stiff wrist* blows be struck. If the ulnar edges of the fingers are used, they can be allowed to fall upon each other, only the little finger touching the skin or the little finger can be flexed somewhat, the next finger a little less and the middle finger left straight and the radial side of the hand slightly turned outward at the impact so that all three fingers strike the skin each time or the hands may be turned palm up and the backs of all the fingers used.

Whether or not hacking or tapotement has been used the treatment for a given area is ended by effleurage administered centripetally.

Vibration is one of the variations of massage that is sometimes used in the attempt to shake a part up. Of all the hundreds of operators we have seen use it (manually) we have never seen one that could equal a fine stroke from a good mechanical vibrator. It is hard to learn to do correctly and too much of a physical strain upon the operator after it is learned, requires constant practice to keep up efficiency and if practiced much by a given operator is prone to cause occupational neuritis so that, in our clinics at least, its use died out almost completely and vibration was done with a mechanical vibrator.

Manipulation is one of the most essential parts of any masage treatment. After the parts have been prepared by preliminary heat and massage (or by conversive heat alone) the limbs are properly supported and the various normal movements of all the joints—flexors, extension, abduction, adduction, circum-

duction, etc.—produced. One or all three forms of motion may be used; active, where the patient does the moving, passive where the operator does it, or resistive where the patient moves the part against proper resistance interposed by the operator. The extent and duration of these movements will have to be governed by the limitations present such as the presence of paralytic muscle which must not be stretched beyond its relaxed length, fibrosed joints with rarefied or disease weakened spots

Fig. 75.—Corner of male massage section.

in bone where leverage might fracture, and ''itis'' which movement might aggravate, etc., etc. As a rule the more acutely painful these movements are the stronger the indication for the use of conversive heat in the place of massage. The movements need not, and often cannot, be made through their normal range but, from day to day their range can be increased. At first a very slight passive movement is all that may be possible and, in fibrosed joints, even this slight movement may be the result of

weeks of daily effort. No fibrosed joint should be pronounced hopeless until long daily treatments with conversive heat, static sparks and condenser discharge, ionizing doses of x-ray on every fifth day and progressively strenuous manipulations have failed. In four years we have succeeded in mobilizing seven knees and securing over 90° motion where the diagnosis, based upon x-ray plates, was "bony ankylosis."

On some of these cases we worked over four months before we succeeded in getting the first slight motion and more than once I have had that awful falling-through-space-with-nausea feeling when watching the strenuous manipulation being administered and the plinth would slip on the floor or a sudden cracking sound would snap out from strain upon some part of the table which made me think for a moment that fracture of a bone had occurred. One of our best aides on this work was in the habit of smiling and remarking when I came up to watch her work upon one of these stubborn cases, "Now Major Sampson, if you will please go answer the telephone it will help. I always hurt you more than the patient. Look at him now, he is not white in the face." One thing was proved repeatedly and that was that a tactful aide could always administer much more force to one of these joints than the man would permit a medical officer or male masseur to apply. Call the psychology what you will, the fact remains. The previous use of conversive heat made the application of any given amount of force much less painful and more efficient and the use of the static after the manipulation to remove the condition of acute strain which, if not so treated, would have been so sore the next day and for many days after that treatments would have had to be suspended and all gain more than lost in the reaction stirred up, was a happy combination and enabled us to intensify the treatment and use it daily. The additional ionizing x-ray dosage was a thing that often enabled us to convert a defeat into a victory.

There are a number of conditions where massage or manipulation is contraindicated. The presence or suspected presence of malignancy absolutely forbids its use. Massage or faradic massage can be used with benefit in acute fibromyositis but

will aggravate an acute neuritis. It can sometimes be used in subacute neuritis and often is beneficial in chronic neuritis. Presence of fracture and undrained pus usually interdict massage and manipulation. It must be used with care, if at all, in active pulmonary tuberculosis and acute febrile conditions generally are best not disturbed by massage as it usually results in increasing the hyperpyrexia. Gastric ulcer may cause a hemorrhage if the stomach is stimulated by gastric or abdominal massage. Because of its stimulant properties it is contraindicated in hyperacidity. The onset or suspected onset of thrombosis should be the signal to cease all massage and manipulation until it is determined whether it has occurred and, if so, until complete organization of the clot has taken place. Even then we prefer to make gentle massage only an adjunct to other methods. Dermatitis, ulceration or a pustular condition of the skin or any condition where infection may be implanted or transferred is a contraindication.

CHAPTER XIX

HYDROTHERAPY

Hydrotherapy, depending upon the method of administering, is either a form of thermotherapy or a combination of thermotherapy and mechanotherapy. If the application of the water is made to the patient in the form of a still bath, packs, etc., then it is a form of plus or minus heat depending upon whether the temperature of the water is above or below the normal skin temperature—around 93° F. If the water is applied from a distance in the form of a hose stream or a modified hose stream such as has been so well named the "fan douche" by the late Dr. Simon Baruch, where the round stream of water issuing from the nozzle is flattened out by pressure of a finger tip on the stream of water or if the water is used while in motion as in the whirlpool bath then a double effect is secured. To the thermal effect is added that of concussion or friction. In the whirlpool bath the friction can be very greatly increased and the bath much improved by fitting the pipe which delivers the water into the bath with an air injector (designed by Capt. F. A. Bardwell) which very much increases the amount of the whirl while at the same time cutting down the amount of water used.

For general hydrotherapy procedures a control table—such as the Baruch control table—with a hot and cold hose, Leonard mixing valves (an arrangement of a mixing chamber with rocker-arm control valves to regulate the temperature of the water issuing from the chamber by simultaneously opening and closing the hot and cold water inlets as an arm is moved from side to side. As the cold water is gradually shut off by the moving of the arm around from left to right the hot water inlet is being opened at the same rate so that the temperature of the water delivered from the mixing chamber rises as the lever is moved to the right and falls as the lever moves to the left reversing the proportions of hot and cold water delivered into the control mixing chamber) pressure meters and thermometer temperature

gauge for each hose is necessary. At a distance from 12 to 14 feet in front of this control table is placed a shower arrangement enclosed on all sides except the one facing the control table. It should be so placed that the patient is about 12 feet from the end of the hose when standing in the center of the douche or spray compartment.

A light bath cabinet is used to prepare the patient for the various douches. This cabinet contains some fifty or more in-

Fig. 76.—Baruch Control Table. Scotch douche. The difficulty of holding the stream so steady during a forty second time exposure that the stream of water did not blur on the negative will show the steadiness of the operator.

candescent light bulbs arranged in vertical rows around the interior so as to subject the whole skin surface of the patient to the action of radiant light and heat. These cabinets are made in all forms from simple wooden cabinets to elaborate metal ones, mirror lined, etc. The usual model is made to have the patient seated upon a central stool but models are made to treat the patient lying at full length. If space permits it is a very marked addition to the effectiveness of the installation to have

one cabinet filled with carbon filament bulbs and a second one filled with mazda tungsten filament bulbs. The carbon bulb cabinet is used where lots of heat quickly applied is wanted as in sensitizing the patient's skin for the Scotch douche in the neuro-vascular training sequence of Baruch. The tungsten bulb filled

Fig. 77.—Cabinet baths. The first is a carbon filament bulb and the one on the left a tungsten filament bulb cabinet.

cabinet is used where elimination is the main object as with this cabinet the patient can be given long treatments and sweated profusely with a minimum of prostration. The cabinets should be so placed that the patient does not have to travel long distances from where he disrobes to enter them and especially so that he has only a short distance to go when he steps out of them

and starts for the douche stand. A patient whose skin has been sensitized in one of these bath cabinets who has to emerge into a cold room, walk barefooted over cold stone floors past open windows and through drafty halls to a hydro room at the other side of the building, take his douches or showers and then (oftentimes before being dried off) promenades back to a dressing room, dressing hurriedly in an overheated room and on out into the air *while sweating* need have very little fear of bad colds or pneumonia if he survives this procedure a few times. He probably is immune. Too much room is a disadvantage in a hydro department unless it is properly laid out.

We are accustomed to dividing all our hydro patients into two big general classes and then subdividing them after we find their reactivity limits. One class is those who need a tonic or neurovascular training course of hydrotherapy such as neurasthenics and convalescents and the other is the large class needing accelerated elimination, such as the various toxemias and suboxidation states. In both classes heart lesion cases are segregated and not given the routine treatment which might easily prove too stimulating.

Both classes are given the preliminary incandescent cabinet light and heat with a difference. Both classes are fitted with a folded bath towel lightly wrung out of cold water and wrapped and moulded around the head. An ordinary bath towel is folded lengthwise until it is about five inches wide and then wrung out of cold water. One end is held on the patient's forehead, the towel carried completely around the head horizontally until it reaches and covers up the free end, the hand holding the free end transferred to hold both the free end and the overlap and then what is left of the towel after the circle around the head is completed is bent at an angle crossed over the top of the head until it meets the band around the head, folded upon itself and again crossed over the top and this is repeated until the whole top of the head is covered. The weight of the folded wet towel is sufficient to hold it in place if properly wound on. This is usually done after the patient is seated in the cabinet with his

head projecting above the rounded aperture for his neck and before the lights are switched on.

If the case is one where the training of the neurovascular reflexes is the main consideration, the patient is placed in the carbon bulb cabinet, all the lights switched on and the skin sensitized by applying a great degree of heat for a short time. The time the patient is left subjected to the action of the light and heat varies with the robustness and reactivity of the patient. In no case is the application long continued as the object is to heat up the skin and this is done rapidly. Our range of time for the carbon bulb cabinet runs from thirty seconds to two and a half minutes with a general average of less than one minute. The object is not to sweat the patient profusely and the evaporation from sweat would lower the temperature of the skin so that a breaking into a profuse sweat is a signal to take the case out of the cabinet and give him the hot and cold douche. The lights may be cut off at any moment the patient complains of any fullness or ringing in the head, dizziness or other symptoms or if the neck vessels begin to show heavy pulsation. As a rule no symptoms whatever will be complained of unless the heat is applied for too long a time. Where one control is being used for several bath cabinets as often happens in large clinics the attendants should time the start of the carbon cabinet patients so that in no instance is one of these cases compelled to wait or stand around after the heat application is finished before he can step into the douche compartment. A few minutes standing around will more than lose any gain from the heat application. The patient should step direct from the cabinet across the room to the douche stand and receive his hot and cold hose (Scotch douche) without delay.

This is best given about as follows: The attendant has already adjusted the temperature of each hose while the patient is in the cabinet so that no time is lost making these adjustments after the patient is on the stand. At the first treatment the cold hose is made a couple of degrees cooler than skin temperature (93° F. is average normal skin temperature) and the hot hose a couple of degrees warmer than normal skin temperature.

The patient's treatment card is before the attendant and the temperature of each hose in *every treatment* is entered upon it *at the time* and the reaction is entered on the following day after questioning the patient. Thus the entry for the first day would be, in addition to the name, diagnosis and prescription at the top of the card which is not changed:

		SCOTCH DOUCHE		TIME SCOTCH	
DATE	CABINET & TIME	HOT HOSE	COLD HOSE	DOUCHE	REACTION
July 5	Carbon—1 min.	95°	91°	1½ min.	slight

A place may be provided for a weekly weight entry and there should be a marginal space for "remarks" under which progress or untoward reaction may be noted. Under some such recording system the reactivity of a given case is no matter for guess, the card plainly showing at what points the maximum extremes of temperature are reached.

The Scotch douche is administered by playing the unmodified stream from the hot hose up and down the spine using just enough pressure so that when the stream is directed upon soft parts such as the buttocks the indentation from the impact of the water can be seen plainly. Start at the base of the spine and *slowly* move the warm hose stream up to the neck and back down the spine to the sacrum. At a call of "turn" from the attendant the patient turns facing the hose and the chest and abdomen are covered in like manner except that on all aspects of the body except over the spine the stream issuing from the hose is modified by the operator of the table laying the tips of the forefinger of the hand holding the hose over the stream as it issues from the nozzle so that the stream is flattened out into a broad sheet of water (named by Dr. Baruch the fan douche). The two sides may also be covered by having the patient turned side to the table, elevate the arm on that side and repeat for the other side. It does little or no additional good to attempt to cover the legs on all sides as the reflexes from the trunk and spine are sufficient and too much time is lost between hoses when the whole body is covered. When the spine and trunk have been hot hosed (slowly) the hot hose is dropped and the cold hose turned on as full as the patient's tolerance will allow (more pressure than

the hot hose but not enough to be traumatic or painful) and an attempt is made to cover the whole spine and trunk as rapidly as possible. The cold hose is played up and down the spine *rapidly* a couple of times and at the call of "turn" the patient starts to pivot and keeps right on until his back is again towards the table when the spine is quickly covered again, the cold hose dropped and the hot hose again brought into play. This is repeated two or three times. We have found this slow warming up with the hot hose and quick cooling down with the cold to work better than where both were used slowly or both used rapidly.

On the second day the temperature of the cold hose is dropped one degree and that of the hot hose is raised one degree. This raising of the temperature a degree a day on the hot hose and lowering it a degree each day on the cold hose can be kept up until the patient complains of the extreme temperature or until the hot hose temperature reaches 110° or 112° and the cold hose 70°. Beyond these points care must be used. If the patient complains of a chill or chilly sensation while dressing or shortly after (assuming that he has not been subjected to drafts or dressing in too warm a room and going out as he breaks into a profuse sweat), if the nails or lips look purple or gooseflesh appears on the body, he is being overtreated. This may be due to too great extremes of temperature, treatments too often or too long, etc. Where it is evident that patients have little vitality, it is well to start them off with two or three treatments a week and gradually work them up to daily treatments or, in many cases, we are in the habit of giving the hydrotherapy three days a week and on each alternate day giving autocondensation treatments. In our hands this combination has worked better than straight daily treatments of either kind.

The duration of the douche ranges from a minute and a half or two minutes at first to four or five minutes at the full dose some days or weeks later. If poor reactions or symptoms show overtreatment, then it is well to shorten down the douche time and if the extremes of temperature are high and low to cut back four or five degrees each way and go along with the lessened dose a

few days. If progress again resumes it may never be necessary to again increase the range of temperature but the time may be increased as improvement justifies.

If the case is one for eliminative hydrotherapy then the patient is placed in the *mazda* bulb cabinet, a cold towel cap applied, given water to drink and left in the cabinet from five to twenty minutes as his robustness and the lack of prostration from the longer periods justify. The mazda cabinet delivers very much more light and very much less heat than the carbon bulb cabinet and produces a copious sweating with a minimum of prostration. After the mazda cabinet bath the patient is given a fan douche following the lines laid down for the Scotch douche except that no such extremes of temperature as are used in training the neurovascular system need be used. If desired a spray starting at about one hundred degrees, running for a few minutes and gradually cooled some ten degrees may be all that is necessary

After all these douches, sprays, etc., the patient is dried, dressed and exercised moderately in fresh air. This is a point well emphasized by the dean of all hydrotherapists, the late Dr. Simon Baruch. I had the pleasure of being one of the last class of officers to whom Dr. Baruch lectured before his death. As a matter of fact the last lecture of the course—a trip to and demonstration in many of the New York City clinics—was never given because of his last illness. Therapists owe this truly grand old man a very heavy debt. His last work, "An Epitome of Hydrotherapy," (W. B. Saunders & Co.) should be in the hands of every therapist. It is full of good points especially as to information on installation, etc., which I shall have to omit on account of space.

I have been through the difficulties incident to having had faulty installation made before I took charge and know the time, trouble and expense of curing one of these "sick" jobs. It is much easier and cheaper to do it right in the first place. A separate water supply is an essential, otherwise a patient may be burned by interference of someone opening a tap at some other point and disturbing the hydrotherapy supply. A hot

water reserve tank large enough to meet all demands from the sprays, douches and whirlpools should be provided else the whole hydrotherapy department will have to shut down at inopportune times while the hot water supply builds up to the proper temperature. The supply should be ample for all needs and so arranged that pressures of from 15 to 40 pounds can be maintained at all times at the douche and still greater pressures on the whirlpools are very desirable.

THE WHIRLPOOL BATH

The whirlpool bath is a bath for the extremities where the water is kept in motion during the bath. Hot and cold pipes lead to a mixing valve (the usual Leonard valve of the control table) and a pipe from the mixing chamber to the bath itself. There are several types of these baths, one type using a turbine arrangement to keep up the agitation in the water, another using compressed air and others using the water pressure itself. The French "eau courante" type was in general use in the reconstruction sections of the service hospitals. Some time ago the manufacturers came out with an "improved" model. The bath itself was now made of monel metal which was a distinct improvement over the previous iron-enamel ones but the shape of both arm and leg whirlpool was changed. This change in both cases resulted in making the bath much larger and more convenient for the use of stiff joint cases—especially the leg whirlpool—but the inertia of a very much larger amount of water and the very great increase in friction from both increased size and changed shape with no provision for increased driving power (the leg has only two nozzles now whereas the older type smaller one had three) makes the newer models much less efficient than the old. Both types are very much improved by being fitted with the air injector designed originally by Capt. F. A. Bardwell of Ft. Snelling and Walter Reed, but if we were installing new whirlpools we would certainly *insist* upon being furnished with the old type, in the monel metal if possible, if not, then in the iron-enamel.

The old type arm bath is shaped exactly like a small baby bath

tub. The old type leg whirlpool is a perfectly round sheet metal tank about twelve or thirteen inches in diameter set at an angle of about 30 degrees from the vertical. In both old types the very much smaller amount of water in the tank, the friction reducing shape and the larger driving force gives a whirl that cannot be

Fig. 78.—Arm whirlpool. The real amount of agitation in the water is poorly shown because of the time exposure necessary but the three strata of water crossing each other at different levels can be made out.

approached in the newer models. This increased whirl increases the efficiency markedly as the immersion of a limb in still water at the same temperature and for the same time gives no such result as the whirlpool. The Bardwell aërator is simply the addition of a device for mixing—automatically—air with the water

just before it issues from the pipes into the bath itself. It consists of a plumber's T-joint let into the line with the side opening pointing up. Into this side opening is screwed a length of straight pipe long enough to reach from the joint to a couple of inches or so above the water level in the bath. This is to furnish the air a path down to the nozzle. Then from the left end of the T-joint and extending all the way through the T-joint or a half inch or so further is soldered or threaded a conical reducing nozzle the distal or small end of which is about ⅓ the diameter of the feed pipe. Into the right end of the T-joint is threaded an extension piece of pipe about four or five inches long and of the full diameter of the size pipe for which the T-joint was made.

Fig. 79.—Film enlargement of a closeup of a leg whirlpool. Note violent agitation of water and presence of numerous air bubbles.

This extension piece of pipe furnishes the necessary room for the nozzle stream to spread out, mix with the air, etc., before going into the tank. Without this extension the device is inoperable. Air is drawn down the raised pipe by suction when the water is issuing from the reduction nozzle and is mixed with the water. About three times the whirl with less than one-third the amount of water results. Before we added these air injectors to our whirlpools we were constantly fighting for more steam pressure to our heaters, adding new heaters to the heating assembly, cutting down the number of whirlpools and stopping the department frequently to accumulate enough hot water to run on. After we installed these injectors we restored the

discarded baths, added two more whirlpools, cut off two of the added flash steam heaters and in addition had to cut down our steam pressure to the ones left. Bardwell's improvement certainly added to the efficiency of our hydrotherapy department.

The whirlpool bath is given by placing the limb to be treated into the bath, starting at a neutral temperature or at any rate less than one hundred degrees and raising the temperature gradually to tolerance (or if anesthesia areas are present to not over 118 degrees) and allowing the bath to continue fifteen to twenty minutes. The heat plus the constant very gentle friction of the continuous flow of bubbles against the skin make the bath very sedative. Limbs so acutely painful that they could not be touched or even given sedative stroking manually were often placed in a few treatments where they could be gently massaged. Open wounds are no contraindication to the bath—in fact they are a good indication. Of course the bath would be sterilized before and after such treatment, but the constant flow of hot water very much lessens the chance of transference of infection. The bath is useful as a precedent to massage or manipulation and is a good treatment for arthritis, tenosynovitis, etc., but not so good as diathermia. Constant use can always be found in any general hospital for the whirlpools.

In the one hydrotherapy section where we had the privilege of designing it we dropped a cement pit about six feet wide and six inches deep across the end of one room and set all the whirlpools in this pit. This at one stroke took care of the copious overflow and made the treatment of stiff hip or knee cases easier as the patient could get his leg into the bath without having to climb up on to a chair to thrust his leg down into the bath. The overflow exit in these baths should be of large caliber so that when they are turned full on the water will not dam up and spill over on to the patient. Some of the earlier models had ridiculously small overflow exits and were almost useless until these openings were enlarged.

I have often been asked my opinion as to the relative value of the whirlpool and the hot paraffine bath. In my mind there is no question but that the whirlpool has the advantage at every

point. The one point the advocates of the hot paraffine bath stress is that patients stand much higher temperatures without burning or blistering; that the limb can be held in a bath of a temperature of 136° F. or more as against a maximum of only 120° for the whirlpool. This is all true but does not mean a thing. The normal skin temperature is around 93° F. This is 43 degrees cooler than the mass of hot paraffine. The instant that *any* substance, flesh or otherwise, 43 degrees cooler than the paraffine is introduced into the paraffine (or if the limb is held in the paraffine while the temperature is raised the same thing holds as the temperature of the skin raises very little) a layer of paraffine is congealed on it. Paraffine is both an electric and a heat insulator, so that whatever heat reaches the skin must pass through this solid layer of paraffine so that it is not strange that it takes some sixteen degrees higher heat to blister the skin in a paraffine bath. As against the impossibility of keeping a paraffine clean; the fact that its use is only that of straight *conductive* heat (the least efficient form); the fact that it leaves the limb coated with paraffine which must be removed before subsequent procedures are carried out and the further fact that its higher temperature is only an apparent advantage and not a real one, are opposed the facts that the whirlpool is much more sanitary and practically self-cleaning; that in addition to the administration of the same amount of *effective* heat there is a very valuable added effect from the constant shower of bubbles and the limb comes out clean and ready for any further procedures without delay. The advantages of the whirlpool are so obvious that we cannot concede a place for the paraffine bath.

THE CONTRAST BATH

The contrast bath is a bath used wherever the production of intense local vasomotor reactions would be of benefit. It was used mainly in the service hospitals for helping to toughen up stumps and as a final stage treatment in some of the trench feet cases.

The part to be treated is immersed in water as hot as can be borne (short of the 120° blister point) for about one minute or more and is then lifted from the hot water and instantly plunged into a vessel of cold water with ice floating in it and held there for twenty or thirty seconds and then the sequence repeated for several minutes. Other procedures such as massage and exercises should follow. In stump cases the exercises consist in fold-

Fig. 80.—Contrast bath in painful stump case.

ing a couple of turkish towels into a square of many thicknesses and having the patient punch the stump down against the towelling laid upon any convenient support for two or three minutes. Sometimes a slight rotary motion imparted to the thrust just at the moment of contact aids in breaking up small adhesions. These thrusts should not be heavy enough to traumatize the stump, but the force usually may be increased at subsequent treatments.

THE CONTINUOUS BATH

The continuous bath is a bath of several hours' duration, given at a temperature ranging from two or three degrees below normal skin temperature to not more than 100° F. Special tubs are provided for its use in institutions and in the service hospitals it was often administered to numbers of the excitable shell shock cases at the same time by seating them around the inside of a large tank or pool. Its sedative properties are too well known to require comment. Its use in functional cardiac cases has also been productive of much good and many cases of abnormal depression have responded well to this kind of bath. Sometimes manipulation of a particularly painful joint may be started under water where the same procedure would not be tolerated in air. In some form (individual tubs or pools) it should form a part of every complete hydrotherapy installation.

CHAPTER XX

ARTHRITIS

If there is any one place in therapy where physical remedies stand out in efficiency, it surely is in the treatment of arthritis. Nothing said here is to be taken to mean that we do not think a differential diagnosis necessary or that an infective arthritis can be successfully cleared up without proper search for, location and elimination of focal areas, etc. It is assumed that all medical men know how to conduct this search and apply adequate measures to the infective area, whether it be tonsils, teeth, sinuses, intestinal, prostatic or what not. After this is done we still have the arthritis with which to deal.

Most of the cases of arthritis that reach a physiotherapy clinic are in the last stages of chronicity although the patient may be and often is in the throes of an acute exacerbation at the time he is sent in for treatment. Many are cases of polyarthritis such as the case illustrated in this chapter and practically all of them have been through every known treatment outside of physiotherapy and many have had one or more disconnected physical remedies used upon them at various times without success. In the face of such facts and the further fact that the staff of one of the arthritic center army medical hospitals was so firmly convinced that we were drawing upon our imagination when we told of similar cases cleared up by physiotherapy that it took some six weeks of the hardest kind of daily pleading before they would consent to allow us to touch one of the cases and then gave us (at our special request) ten of the worst cases to treat, it may not be out of place to state that when the report to the staff was made by the officers designated to check up results secured in these ten cases at the ten o'clock morning meeting we found upon coming into the hospital from noon mess the exceedingly large hall (over two hundred feet long) filled with arthritics on stretchers, wheel chairs, crutches and canes waiting a chance to get onto the treatment list of the clinic and the department bounded from a two room department

to one of sixteen large rooms and the parting word of the Colonel commanding when we were later on transferred was, "I consider the work of your service here in this hospital nothing short of marvelous and only hope that we may soon again find ourselves on duty in the same hospital."

There is no such thing in our clinic as a set treatment for a given diagnosis. Each case is prescribed for upon its merits and the prescription for arthritis in different individuals is no excep-

Fig. 81.—Polyarthritis complicated by gas bronchitis and asthma. Many of these extreme cases were sent to the physiotherapy service on litters and in wheel chairs. This man's joints were so badly inflamed that he could not stand to be handled even in the most gentle manner and he had to be treated by lifting his wheel chair upon the static platform. Some of these cases made a wonderful improvement under diathermia, ultraviolet ray, static, ionizing doses of x-ray and massage and manipulation in the later stages of the treatment. Many cases cleared up entirely, all improved under treatment and only a very few having multiple foci of infection proved to be resistant to treatment.

tion to the rule. By summing up the procedures that have been most generally successful, however, we find two physical remedies that stand out above all others. These two are the static and conversive heat. The static alone—sparks, effluve, condenser discharge—will often abate an acute attack but we find that on all the chronic cases and most of the acute that conversive heat through

the joint and tissues above and below is very essential to success. This alone will control the pain and start resolution in quite a percentage of acute cases but static is such a valuable addition that we would hate to have to treat many cases of arthritis without it.

For the local pathology then we would apply sedative diathermia followed if possible by static sparks, effluve and condenser discharge. The sparks are applied up and down the limb above and below the joint, around the joint itself (avoiding striking the bony points) until the whole area has been covered, the strength of the sparks being quickly increased to the maximum tolerance after the first treatment or two. If the patient is exceedingly emaciated, weak and pain-shy it may be necessary, in order to allay his fears and give you time to jack his courage up to the sticking point, to give nothing but the effluve at the first two or three treatments, assuring him that it is not the least bit painful but will give some relief. Then you can explain that it does not go deep enough to have permanent effect and that the sparks will penetrate but will be more or less painful at first. It is astonishing how quickly these patients acquire tolerance for sparks and seemingly some of the weakest cases stand the strongest sparks. The stronger you can push the length of the spark in the first few treatments the faster will subsequent progress be. It is mistaken sympathy to baby these arthritic cases. It requires some apparently very rough treatment for a few treatments before marked progress can be made. It is quite necessary—especially in the more chronic cases—to secure a marked reaction from the treatment and of course during this reaction (which need not last over one, two or three days) the patient is going to feel worse. If you do not push treatment to this reaction stage on many of the more stubborn cases you will fail to clear them up. I am in the habit of stating in our lectures upon arthritis that if we cannot succeed in making an arthritic worse then we cannot succeed in making him better but this applies more to the stubborn chronic cases. When this reaction to the heavy sparks is secured, then the amount of sparks given as well as the length may be cut down. After the sparks the effluve is given, going over the area covered by the sparks several times, slowly. This is a very sedative procedure after the sparks. Then a crookes metal electrode of proper size

and shape (the size adapted to the size of the static machine) is applied around the joint and about 15 to 20 minutes of the condenser discharge is given. If more than one joint is affected and you have a good sixteen plate machine or larger it may be possible to treat two large joints—say knees—at one time by making the electrodes slightly narrower and hitching both to the positive pole of the static, the rest of the hookup being just the same as if only one electrode were being used.

If a static machine is not to be had then massage and manipulation will have to take the place of the static as well as can be managed. The manipulations will be increased as rapidly as possible, more and more range being added to the movements of the joint as the inflammatory symptoms subside. Ionizing dosages of x-ray are administered to the affected joints and the surrounding tissues every five or six days.

If a good diathermia machine is not available then some other form of heat will have to be substituted but no other form of heat is nearly so good as the conversive. Probably the whirlpool bath with the Bardwell air injector principle attachment is the next best substitute in these cases and radiant light and heat from the 1500 watt lamp next.

The sedative massage effect of showers of fine air bubbles rising through the water and rubbing the skin in their passage added to the heat makes this form of whirlpool much better than one without the air bubbles. The old type of whirlpool is also much better than the new type.

The addition of general ultraviolet exposures helps take care of any suboxidation states. These ultraviolet exposures need not be given too strong. A mild second degree erythema is all that it is necessary to produce in most localities, but we have given heavy third degree reactions over the joints with benefit in some of the more refractory cases and have given compression fourth degree exposures in a few of the cases where teno-synovitis was a stubborn complication.

Where preferred, instead of the ultraviolet general exposures, elimination may be hastened by giving daily autocondensation treatments or daily elimination hydro treatments or the two may be combined, the hydro being given on one day and the autocon-

densation the next, etc. I believe that the alternation gives better results than either one used singly.

If ankylosis of one or more joints has taken place before the case comes in for treatment, then the regular treatment for breaking up massive fibrosis—diathermia, forcible manipulation, static and ionizing dosages of x-ray—will have to be carried out.

The treatment of gonorrheal arthritis differs in no important respect from that of traumatic or infective arthritis except that similar treatment is directed at the focus. For many years I thought and said that diathermia was contraindicated in neisserian arthritis, but I later found out that this apparent truth was due to the fact that nonresonant outfits were being used and poor technic was resulting in irritation instead of sedation. I have used diathermia in these cases very successfully since I revised my technics and adopted resonant machines.

In the male the focus is usually the prostate or swollen, occluded seminal vesicles. Where swelling prevents drainage in these places, it is futile to attack a joint with any hope of clearing it up as reinfection will occur with clocklike regularity. I well remember one particular case that I treated for years in my early days. As fast as I would relieve a wrist, a knee would flare up. Clear that and an ankle, a shoulder, then a hand, etc. I wished the case off onto others to treat at every annual vacation that I took and hoped against hope that I would never hear of the man again but he always came back. When I ceased practice in his city some nine years ago he was still having these recurring attacks. I have since succeeded in clearing up many similar cases. I now treat the focus by giving diathermia with a curved metal electrode in the rectum and a crookes metal, kidney-shaped electrode, soaped, and applied just over the symphysis pubis. This electrode is three or four inches long, one and a half to two or more inches wide and applied with the convexity up, the concavity down and fitting around the pubis. The two cords from the d'Arsonval circuit are attached, one to each electrode, the sedative technic used and from five to seven hundred milliamperes given for nearly an hour, or even more than an hour if possible, daily or twice a day for the first few days. We follow this with the static condenser discharge or the Morse sine wave or some modality to produce a nontraumatic massage and end the treatment by an ultraviolet exposure

to the prostatic rectal mucosa through the quartz vacuum prostatic applicator of McCaskey's design or any suitable applicator. The ultraviolet is given long enough to produce a good second degree erythema and repeated every few days as the reaction subsides. An overdose, producing a third degree reaction will be characterized by a hot, bearing down pain and pain at stools with, possibly, a little blood and strips of mucosa in the stool. Outside the moderate amount of discomfort to the patient (he is not usually particularly comfortable anyhow) an overdose does no harm. As a matter of fact, if progress in a given case is slow we are in the habit of deliberately giving an overdose of ultraviolet and are sure that progress was markedly accelerated in a number of cases. Feces are no exception to the inability of ultraviolet to penetrate and a dirty mucosa will not receive any ultraviolet no matter how long the exposures are made. The best way, of course, to clean off the mucosa is to give a copious warm soap or other enema but if enemas are impracticable then at least have a free saline purge action produced the day the ultraviolet is to be given. If the sphincter area (on account of its tighter coaptation and nearness to the lamp) receives too much ultraviolet as compared to the bowel mucosa higher up then a coat of vaseline or a more opaque ointment such as zinc oxide may be smeared around the quartz at the point where it makes contact with the sphincter but care should be taken that none of this opaque substance is allowed to get upon the quartz of the upper end. I am in the habit of placing a few drops of a liquid antiseptic soap upon the end of the electrode to act as a lubricant, as almost any ointment, even the non-greasy ones if spread too thick, will at times cut down the amount of ray being delivered. If a metal proctoscope is used—and much of our best work was done before the vacuum quartz applicator was designed—a sharp localizer can be used and inserted into the proctoscope and no thought need be taken for the sphincter mucosa.

A reaction of the external skin from the ultraviolet seems to help in these cases. I usually produce a second degree over the perineum, buttocks, scrotum, etc., so that the absorption of reaction products will be from as near an area as possible. It is seldom necessary to go in through the urethra with the ultraviolet as the rectal port almost always will permit of plenty of reaction

being produced to do the work. Heat may be applied to the prostatic urethra by means of the nonvacuum electrode if there is indication for it but usually the much wider distributed heat of direct diathermia is preferable in these cases.

Can arthritis deformans be "cured?" It depends upon the definition of the word "cure." The dictionary gives you about as many guesses as you wish as to the meaning of the word so I shall have to settle that point before I answer yes or no. If, by cure, we mean an absolute damping out of the arthritis plus a complete restoration of function and a removal of all deformities, then certainly none except early cases before any deformity has occurred can be cured. If this rigid construction of the word cure is to be held to then the number of "cures" that can be performed upon any chronic disease by *any* therapeutic procedure is practically zero. If, by cure, we mean a stopping and removal of the *arthritis* so that no further damage is inflicted and a restoration of function up to the point permissible by the *damage already done* can be made, then this condition is as curable as almost any other chronic process. In other words, the arthritis can almost surely be cured but the deformity may be, and probably is, permanent. It is not an easy task in any event and persistence is the keynote of success. Removal of all sources of infection is a prerequisite. Teeth, sinuses, tonsils, intestinal tract including liver and gall bladder, etc., must be eliminated as constant feeders of infection before any local treatment will result in damping out the arthritis permanently. A few proper local treatments give such prompt and marked relief that it is very often difficult and many times impossible to prevail upon these sufferers to continue their treatments. The picture does not need to be overdrawn to show them the fatal mistake of ceasing treatment as soon as relief is obtained. Relief of pain is only the *first* symptom of improvement and if treatment is stopped at this point all that has been gained is a few weeks or months halting of the destructive process which will surely light up again and go right on if an unquenched smoulder of "itis" is left *in situ.*

As in any other arthritis the principal weapons are conversive heat and static. The method of applying the diathermia will vary with the joint or joints affected. All the joints of hands or feet may be treated at the same time by the double cuff-salt water

method. If the knees are affected cuffs several inches above and below will answer. It is always well to include as much of the surrounding structures as possible in the treated areas as the changes are not entirely confined to the joints. After the sedative diathermia the static condenser discharge or sparks and the condenser discharge and once a week the ionizing x-ray dosage. In the absence of static electricity, massage and manipulation may be used. Manipulation is used in any event. General ultraviolet is a valuable addition. In the absence of this general high frequency (autocondensation) or that combined with eliminative hydrotherapy on alternative days is very valuable. There is no doubt in our mind that the general ultraviolet easily ranks the other procedures as an aid to elimination and as a general tonic.

CHAPTER XXI

LOCOMOTOR ATAXIA

Any treatment said to be of benefit in locomotor ataxia cases I am almost painfully aware, must run the gantlet repeatedly before being allowed to take its place among accepted procedures. The treatment I am going to outline—which has proved even better than I had hoped for when I originated it several years ago—is not the result of a few moments study and a lucky mixing of what just happened to be a correct formula, but slowly took form as a result of many years of hard study and experimentation in private practice, physical laboratory and physiotherapy service clinics. Much of the technic is the result of things learned in a several year research (finally successful) for some way to minimize or clear up the destructive pathology following overdosage of x-ray.

In many ways the destructive pathology of locomotor ataxia resembles that of a chronic x-ray "burn." The pain, interference with nutrition and slow destruction of tissues from compression by chronically inflamed, slowly contracting fibrous tissue—even in the arterioles—is progressive in both cases and no known combination of drugs is capable of arresting it once it has been established. The repeated amputations, engrafting of cancer upon the intensely irritated area, the futility of surgical and medical procedures in bad x-ray burn and the high mortality are all well known. The increasing pain, lingering and progressive disability and final inevitable (if not sooner) death awaiting every sufferer from locomotor ataxia makes *any good results whatever* a distinct gain in the treatment of this condition.

Because of the resistance surrounded and insulated location of the cord we are barred from obtaining results by the use of any of the low tension currents, conductive or convective heat, direct ultraviolet exposures, manual massage, etc., which we use so frequently in the softer and more superficial tissues. We are limited to the use of those physical agencies having a high degree of pene-

tration so that they will not only penetrate the muscles, fascia, bone, etc., but also the fluid surrounding the cord and produce their characteristic effect upon the cord itself as well as upon the nerves emerging from it. We must have something that will penetrate to and heat up the cord and especially the meninges and connective tissue stroma. We must have something to produce instant and vigorous contractions in all contractile tissue in the cord and blood vessels. In addition, to start a retrograde process in the organized fibrosis, we must ionize this tissue at regular intervals with some agency that will affect the denser fibrous tissue but not damage the neurons, that will have penetration enough to reach all parts evenly. There is no reason why a treatment that will remove fibrosis or clear up a neuritis in one nerve will not do it in another provided the latter can be reached with the same treatment in equal intensity. The treatment for optic neuritis is only a milder modification of that for sciatic neuritis made necessary by the delicate and easily reached structure of the optic nerve, and the cord, by the same resistant properties which makes it impossible to reach it with the low tension remedies, is all the easier to treat when remedies such as conversive heat—which *depends upon* resistance for its efficiency—are used. One has only to have seen the almost instant improvement which always takes place in endarteritis obliterans under proper diathermia in a sufficiently large number of cases to recognize that here we have a remedy which is so efficient in this very stubborn condition as practically to amount to a specific. One has only to know the physics of high frequency to know that here is a remedy that can be used in the cord if it is indicated. One has only to remember his pathology in luetic conditions to be certain that the blood vessels are involved no matter what other involvement there is present, and that the gradual obliteration of the arterioles is from the same cause that produces compression of neurons in a nerve, intense pain, loss of function and years later—if compression be not relieved meanwhile—ultimate degeneration of the neuron with consequent *permanent* damage. One has only to have used diathermia in a large variety of neurites to know that it is the best possible basic remedy where the process is chronic and that it is just as efficient in neuritis as in arteritis. When it is further remembered that the paralysis of a neuritis will disappear when the neuritis is cleared up (unde-

generated neurons will resume function if compression is removed before degeneration has started) and that any neuron that is screaming with pain has not yet degenerated it will be seen that any ataxic that is having pain is amenable to improvement if such compression can be removed.

We have, then, for our attack upon the pathology in the cord three high penetration physical remedies, each with a different physical, chemical or physiochemical reaction and each strongly indicated, viz., the most efficient kind of heat—conversive heat—in the form of diathermia for its heating and solvent effect, to open up afferent and efferent channels, increase metabolism and carry away the broken down inflammatory products, the static condenser discharge to mechanically, vigorously but nontraumatically massage every bit of contractile tissue, aiding in cleaning up the area much as alternately compressing and relaxing a dirty sponge in warm water cleans it and lastly, ionizing doses of soft x-ray for its chemical solvent effect upon the pathological tissues.

When diathermia alone is used, the softer parts expand more than the membranes and bone and additional pressure is created which converts what should be an active, arterial hyperemia into a passive hyperemia, still further interferes with an already poor circulation, increases inflammation and pain and every way aggravates the condition.

When the static condenser discharge alone is used, the tissues are cold, nonelastic from the presence of much old inflammatory residue and cannot be contracted so that the use of static electricity alone will not result in any material gain. When the ''frozen'' area is first thawed out by diathermia and then static electricity applied a different state of affairs exists. When the static is applied according to the technic laid down under the static condenser section (unless this technic is followed the contractions produced—if any—are so weak that they are wholly or nearly ineffectual) the heated tissues are contracted, blood expressed or sent on its way, while the condenser is charging for the next discharge the parts again relax and fill with blood, which is now much warmer than when it entered the heated area and at the next condenser discharge more blood is pumped out, more of the residual heat is carried out of the area and by a *rhythmic, slow* repetition of this action (possible only with absolute control of the

frequency of discharge of condensers and this possible only with technic given) the area is thoroughly washed out with hot blood under pressure and by the time the treatment is finished, enough of the heat has been carried out so that what remains is beneficial instead of a detriment.

If the x-ray alone is used (it must be used in ionizing dosage; large dosage *causes* the very thing we are fighting) the tissues are cold, less sensitive and the *very diffuse* effect of these small dosages is not sufficient to do more than dissolve some of the more recent and finer processes at the edge of the area and these reform by extension as soon as the x-ray is discontinued. The diffuse change produced in the older processes is lost because reorganization takes place if the ionized products *are not removed.* We have repeatedly tried each one of these remedies separately and in pairs without avail. They must be used together to secure maximum results.

The correct procedure is to thoroughly heat the spine with direct diathermia, follow immediately with the static condenser discharge and repeat these procedures daily for many weeks. Once every five, six or seven days the entire brain and cord should be ionized with five milliampere minutes (not 5 ma. for 5 minutes, which would be 25 ma. min.) of a five inch back-up spark x-ray through one millimeter of aluminum filter at an eight inch target-skin distance. We realize that this is a very small amount of x-ray, but we know from experience that it is enough to do what we wish to have done. We found in treating large numbers of gas bronchitis and asthmatic cases that sometimes the difference between three and three and one-half milliampere minute doses with these factors was the difference between comfort and progress and acute discomfort and retrogression. We also found that if the x-ray were administered oftener than every five days that the effect was cumulative. If the tube stand you have will not permit of reaching an eight inch target-skin distance, longer target-skin distance and proportionately longer exposure may be used such as 7½ ma. min. at ten inches, etc.

For diathermia use a resonant outfit and the sedative technic with a narrow flexible metal electrode on the spine, (1½ to 2 inches wide) the length depending upon the capacity of the transformer, and a much wider one of the same length on the anterior

surface of the body. It does no harm greatly to exceed the usual twenty minute time—in fact at first is beneficial. After the case has shown marked improvement, the time may be cut back to twenty minutes and later treatments given every other day instead of every day. The static condenser should be given from a narrow metal electrode (width also proportional to size of machine) covering the same spinal area which has just been heated up with the diathermia. If too wide an electrode is used, the density of current is lessened and less effect is produced in tissues under the electrode. The rate of condenser discharges should never be allowed to take place oftener than *twice per second* else the tissues are not given time between contractions to refill with blood. Very few portable high frequency outfits are of sufficient capacity to do spinal work and if one is used the length of the electrodes will have to be shortened and the spine treated in sections. The same with the static. If a small machine or one not delivering a good heavy discharge is used then reduce size of electrode and treat in segments.

Right here the objection will probably occur to the reader, "The writer stated very positively in a chapter on diathermia that that modality was the most intensely sedative physical modality used in physiotherapy and that the sedation of contractile tissue after its proper application was so great that proper diagnostic tests could not be made for several days or weeks after its use. How, then, does he expect to massage (contract and expand) the structure of the spinal cord if he precedes the static wave with diathermia?" The answer is the statement of exactly the same fact that causes a diathermia treatment to fail if given for sedative and absorptive purposes with a dirty spark gap or with a clean spark gap too widely open. In testing for progress of regeneration in peripheral nerve injury with the muscle testing condenser set, with a given number of condenser sections cut in, if no response is obtained with the voltage entering the condenser set at 100 volts and with no other change than the increasing of the voltage to 125 volts very often a response can be obtained. This from a difference of 25 volts. With the static condenser properly used, the condensers are charging not at 125 volts, but at much more than a hundred thousand volts and there is a correspondingly great increase in the ability to produce contractions, therefore the

action of diathermia in preventing contractions under the static condenser discharge is practically nil.

Other treatment, such as re-educational exercises, mental training, etc., will be added at appropriate times. Every one of these cases has a phobia (not without reason) and, because of previous failures, mental training instituted before physical improvement has set in will probably do little good. One of the most fascinating things in therapy is the observance of the radical change in the viewpoint of life as exhibited by these poor sufferers as they realize that, *at last,* something real is being done for them.

One of the first things noted under this treatment is a marked or complete relief of pain after a few treatments. The ability to stand alone with the eyes closed will probably be the next thing noted although some patients remark about how much easier they can get around than formerly before they show ability to stand erect with the eyes closed. They become able to take steps without looking to see just where their feet are going to fall and in some of our cases were able to drive a car at night without having the foot pedals and controls illuminated. A little later they are able to walk twenty or thirty feet in a perfectly straight line with a bandage over their eyes. After from three to six weeks we have several times noted a persistently negative spinal Wassermann become positive and the treatment is not complete, no matter how great the improvement or whether a positive Wassermann appears or not, until a specific course of salvarsan and mercury has been administered.

These cases should be treated physically until long after they cease showing steady improvement as we have seen them improve for a few weeks, remain stationary or even slip back a little and later pick up and come along well. They should also be impressed with the importance of coming in for an examination every few months for a long time and told to come in upon the appearance of any "intercurrent" pain or cold which—if neglected—might cause them trouble. It is not well to suggest to them that they *might relapse* as they take these suggestions all too easily. Discourage them from talking over their ailment or treatment with foreign physicians who neither know nor appreciate what you are trying to do for them. It has been a part of my experience that cases just beginning to make slow but sure progress under this

treatment have stopped their treatment suddenly after having been assured by some more or less authority upon this subject that they were being deceived and have continued their treatment later on when their symptoms began to recur under the *scientific* administration of an "expert" whose heaviest scientific training up to a few short months before had been shoeing a horse or something equally difficult mentally, but who had answered a mail order school ad, bought a short circuit license to practice therapy (legalized in many states) and commenced curing easy cases like locomotor ataxia.

In the twelve cases I now have under treatment (February, 1922) (no case is included that has less than five months' treatment) all have lost their pains, eleven have lost their inability to stand alone with their eyes closed, eleven can walk a straight line for twenty feet with eyes closed, ten now have Wassermann negative spinal fluids, all have improved markedly in their gait. None of these cases could stand a moment with their eyes closed or walk a straight line before the physical treatment. I cannot testify as to the permanence of this marked clinical improvement but the few cases I have been able to trace over a few years after cessation of treatment have shown no signs of any renewed activity of the process and as the improvement was gained by a *removal of the pathology* there is no reason to think that relapses will occur unless the removal process is stopped too soon.

I reported this series of cases at a recent joint clinical session of the American Electrotherapeutic and the New York Electrotherapeutic Societies held in the physiotherapy service clinic at the Fox Hills Hospital, December 29, 30, 1921. I did not report another much larger series of cases that I had treated in the same clinic in the days when the hospital had been an army hospital for the reason that the first series of cases had all been discharged or transferred over a year before, their complete case histories were not available and the medical officers were all transferred. I reported only those cases that were still in the hospital, whose records were available and whose treatment the present staff had witnessed and could verify. I reported eleven of these cases as completely cleared up clinically or markedly improved and one case as unimproved. When the presentation of cases was finished and the discussion started the neuropsychiatrist for the hospital arose

and stated several relevant facts among which were: that this series of cases had been incorrectly reported; that the physiotherapist—from his own personal knowledge—was too busy with the large number of cases going through the physiotherapy and occupational therapy section daily (under the United States Public Health Service the two are grouped under one head and called the Reconstruction Department and my title was that of "Reconstruction Officer") to do more than give each case a more or less hurried examination at intervals of several weeks apart; that he, himself, had been running a series of tests on these cases several times a week; that the reconstruction officer was not a specialist in this particular line whereas he was and had been for years and therefore, he contended, was better able to judge whether improvement had or had not been made; that he did not approve of allowing any doctor—least of all a reconstruction officer—to get away with a wrong report especially upon such a serious matter, and in other ways tested my self-control to the very limit before springing his climax. When he had reached this very tense point he relieved the tension and led the laugh which followed his statement by saying that he could take no issue on eleven of the cases but that the twelfth had been reported wrong. That, as a matter of fact, the case that had been reported as "unimproved" had made a decided improvement in the last thirty days and was improving very fast at the present time and proceeded to prove his statement. My alibi was that the tremendous amount of detail connected with organizing and successfully putting on the clinic in addition to the real job of carrying on had, possibly, caused me to omit routine examinations upon some of the less serious cases and that I had a feeling that a percentage of improvement of 90 in such a series was so large that I was glad to report a failure, anyway.

CHAPTER XXII

PYORRHEA ALVEOLARIS (RIGG'S DISEASE)

It has often been said that the person who, knowing little or nothing of the deadly danger of his actions, rushes into some perilous combat and by the very audacity of his act and without much other effort being needed succeeds in turning defeat into victory deserves no credit for bravery and is more or less of a fool. The same can hardly be said of one who realizes every bit of the danger and is mortally afraid of it yet, knowing also the psychology involved, compels himself to take the chance. I shall ask only that my dental friends believe me when I say that were the question solely one of a local pathology involving only local destruction and therefore one entirely within the province of the dental surgeon instead of a local condition that is, more often than not, the focus from which travels infection to nerves, muscles, joints and vital organs resulting in much pain and disability or even death to the host and in arteriosclerosis to the physician worrying over these sequelae in their patients, I would cheerfully pass up any mention of this condition, let alone any suggestions as to its treatment. If I did not further believe that I could add something at least to the effectiveness of the attack upon this widespread condition I would refrain from rushing in upon the discussion of its treatment.

I do not know to whom credit should be given for priority in treating pyorrhea with ultraviolet light, and would mention his name if I could settle the point. I do not claim priority and refuse to enter any controversy over such an unimportant point. I took up the treatment of pyorrhea with the ultraviolet light as a result of my success in using the actinic ray upon other stubborn infective, pustular conditions and evolved my own technic from knowledge gained both in the clinic and research laboratory. My interest in the subject is quite personal as I had been a sufferer from pyorrhea since childhood, had had repeated apical abscesses, lost several teeth, suffered acutely from neuritis for weeks at a time

upon several occasions, had a physical breakdown from toxemia, various arthritic attacks, etc., and had undergone years of local treatments in an attempt to clear up the pyorrheic processes before I succeeded in solving the problem in my own case. A few years ago I reached a point where only the insistent advice of a trusted friend who was also a finely trained dental surgeon prevented me from carrying out the advice of other dental consultants and having every tooth in my mouth extracted. It is hard to realize even now how nearly he hit off the truth when he listed my mental deficiencies and having had this experience with him makes me more or less indifferent to what anyone else could ever say to or about me. I thank him for this degree of immunity.

Much can be done for the exceedingly troublesome condition known as Rigg's disease provided proper apparatus and technic are used. That provision, however, is all important. When a paper expert* is an ordinary physician, the technic he advocates is more or less unimportant but when he gets into a position where any technic he puts out is going to be accepted without question (both by virtue of his connections and because of the tremendous publicity given his writings) by thousands of physicians and dentists and as valuable a thing as ultraviolet *judged* and accepted or condemned on a trial based upon his technic then he should *know* the merits of any procedures he advocates or should expect to have their deficiencies pointed out. I am not going to remain quiet in the face of the fact that results following a trial of such technic are almost daily being quoted to me as disproving statements I make founded upon use of an older and better technic.

It resolves down to a question of the relative merits of two different sets of procedures or technics, so we shall do a little analysis.

If a technic in use has proved unsuccessful or only partially successful then there may be excuse for devising a much more complicated technic to replace it. The much more complicated technic should have, at least, a measure of increased efficiency to justify any one trying to popularize it and secure its general

*Paper expert: A man without practical clinical experience in certain lines who devotes much of his time to writing elaborate papers upon such simple subjects. Any such man who attempts to short cut himself into a reputation via the "scientific" paper route. Averages about one "original" technic per ream of paper, hence the designation—paper expert.

adoption. If it not only does not have this increased efficiency but has a very much lowered efficiency and its author keeps on trying to make it the standard technic after its deficiencies have been pointed out then either his judgment or his motives must be questioned.

Let us take the old contact-pressure and the new adrenalin-decolorized-eosin-no-pressure technics and compare them point by point.

Tubercle bacilli on culture media in a test tube may be rayed with almost any dosage from the most powerful Coolidge tube x-ray outfit, a small amount injected into guinea pigs at the end of the raying and they will proceed to kill the animal in their characteristic way. A small amount of the same culture of germs—before this treatment in the test tube—may be injected into the glands of another guinea pig, given time to set up their destructive process and given a *very small fraction* of the quantity of x-rays administered to the test tube germs without effect, and the result almost always (provided the dosage is correct) is a killing out of the germs and a clearing up of the process started by their injection. What does this prove if it does not prove that the x-ray *itself* has no germicidal effect upon the bacillus tuberculosis? The only difference in the two treatments is that the culture media in the test tube has no power of reaction whatever and the adenoid tissue in the living animal is decidedly sensitive to the x-ray, reacting under very moderate dosage. Then it is not the ray itself but the reaction stirred up by the ray that does the work. The ultraviolet on the other hand has a *decidedly* lethal effect upon all germs and would do the work *quicker and better* than the x-ray—because of this germicidal effect and because much more violent tissue reaction can be produced with perfect safety with it than can be done with the x-ray—if it could be used but it has a limitation not possessed by the x-ray—that of lack of penetration. It will not penetrate any living tissue to any depth effective in these conditions because it will not go through blood. This little limitation offers a good chance to change a technic around, "improve" and complicate it so the very happy thought occurs: Dehematize the area with adrenalin instead of by compression which has been used before. So, instead of compression, adrenalin is used and a new touch (?) imparted by applying the ultraviolet ray through

decolorized eosin solution in order to get the ray into all the corners and pockets. This new technic for pyorrhea has almost as many faults as the famous "actino-quantimeter unit" had. The greatest of these is that it is decidedly inefficient as compared to a much simpler procedure.

It is not necessary for the ultraviolet ray to reach every part of the area under treatment if a tissue reaction intense enough to *spread to* this area can be produced in the locality. Because of the anatomy of the gums this is easily possible provided a sufficiently powerful lamp and compression be used. Not even *compression* however will provoke this intense reaction—*a sine qua non*—if the very reflex that forms it, the vasomotor mechanism, is locked tightly for some hours by the application of adrenalin. In adrenalinized tissues only a *delayed* reaction of very much reduced intensity (and therefore much less efficient) can be produced. No *surface* reaction produced by transmission of the ray through a solution of eosin can be as intense as the reaction from compression, or can penetrate to the *depths necessary* to *sterilize the whole area.* It needs only a few trials of both methods to convince any one of this fact. Decolorized eosin is very well to use as a makeshift in deep sinuses and such places where direct access or compression cannot be applied. By pressure, not only is the depth of penetration increased, but the increased mass of tissue inflamed will cause a spread of the inflammatory reaction far beyond the limits to which *any* reaction produced upon the surface would ever spread. This can easily be proved by making a fourth degree erythema exposure (blister) with the end of the quartz rod barely touching the skin of the forearm. No matter how much *overexposure* is given, a blister is all that will result. Then, on the same general area but an inch or so away give a double blister exposure *under compression* and note the surrounding inflammatory reaction zone which will extend for more than half an inch in all directions from the point of contact. Germs barely under the skin would not be sterilized from the first method but any germ in the inflamed area of the second exposure would be killed. Thus, *assuming* that the decolorized eosin conducts the ultraviolet light evenly to all parts of the cavity surface and that reactivity is not interferred with by the use of

adrenalin, you still would have a surface reaction with its limitations as compared to a deep, widespread reaction from the pressure method.

To test out the relative merits of the two methods under the *most fair conditions possible,* I had the author of the no-pressure-adrenalin-decolorized-eosin technic, personally, give me a maximum exposure on my own gums on two alternate days and the reaction of this *double* exposure was so slight as not to be visible from a casual survey of the inside of the mouth. I had previously tried it on other cases but wanted to be fair and try each method with absolutely correct technic on a single individual where differences of reactivity could be ruled out. On the other side of the mouth I used one full compression treatment covering only the area of one tooth (six exposures—3 lingual—3 labial) and within thirty-six hours the reaction was such that it was prominently visible across the room and I had difficulty in convincing my friends that I had not stepped into a straight-arm punch. This latter reaction was produced with a special solid quartz rod applicator made for me by Mr. Berry of the General Electric Laboratories at West Lynn, Mass. Up to that time compression treatments had been given through air filled, quartz tipped applicators. Since that time both the Burdick (and later the Victor Company) and Hanovia Companies have made these applicators standard on their supply list. Even these light reactions of the adrenalin technic *are* of benefit and, repeated often enough, undoubtedly will help clear up a pyorrheic process, but why fool along with repeated light reactions requiring a complicated technic and little more efficient than those secured by local applications of trichloracetic acid, etc., when one good reaction, much easier produced, will settle the argument?

The first step in the compression treatment is to secure a good water cooled ultraviolet lamp and a proper quartz rod applicator. The quartz rod should be of the best quality quartz and should be *absolutely free from bubbles of air* else much of the most desirable part of the rays (the very shortest, most irritating, most soluble and most easily refracted rays) will either

be absorbed or refracted and not reach the *end* of the applicator where they must be delivered to be of any value. A lamp and applicator that will not blister the mucous membrane in less than a one minute compression exposure will hardly give the very intense reactions necessary to sterilize these areas in one treatment. At first I designed a full set of quartz applicators consisting of four separate pieces, a straight, a 45° angle, a 90° angle and a 130° angle. Due to the much greater loss of rays in the 130° angle applicator we seldom use it any more and use the 45° angle one wherever we can, using the 90° angle one only for the molars. We find that, by positioning the head, the 45° can be used for all the lingual side applications except in cases of very high roof mouths where the rear of the incisors may require the use of the 90° applicator. On the labial side the 90° will have to be used on some of the molars.

Have a good dental surgeon scrape the teeth to be treated *thoroughly* but instruct him *not* to apply trichloracetic, silver nitrate, iodin or anything of a cauterant nature. Unless the patient does not object to having the side of the face greatly swollen it is well not to treat more than a couple of teeth at a sitting in which case it is well to have only those teeth to be treated scraped, leaving the others to be scraped just preceding the ultraviolet treatments. This swelling will be marked but not particularly painful; not nearly so painful as the swelling from an ulcerated tooth, for instance. It will start a few hours after the ultraviolet treatment, progress for about thirty-six hours and then subside rapidly.

If your lamp has more than one voltage running adjustment, run it from the highest voltage the lamp will stand. Light the lamp, run it up to the voltage to be used by the proper steps, giving it at least five or six minutes to reach the maximum voltage, put on the selected quartz rod and (the teeth to be treated having been scraped clear of all scales, etc.) make the exposures somewhat as outlined in the Fig. 82. These exposures should be made on the gums on both labial and lingual sides of the tooth and should aim to take in all the tissue between the teeth as well as up to the apex.

The mere production of a blister on the gums is not enough. A violent *tissue reaction* is necessary if the treatment is to succeed. Find what the blister or fourth degree erythema exposure time is on mucous membrane for your lamp and the *particular applicator you are using* and then double the exposure time at each exposure. If your lamp will blister in forty seconds then give 70 or 80 seconds contact-under-pressure exposure or more. The pressure used should not be enough to break the quartz rod but should be enough to visibly whiten the gum under the end of the applicator. Do not cocainize these areas for the same

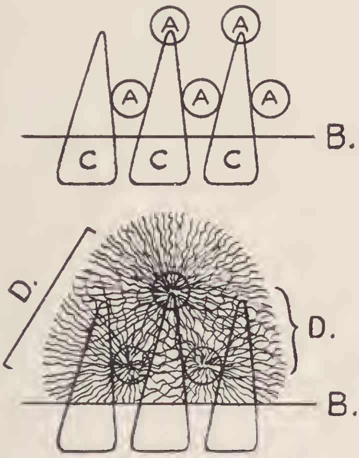

Fig. 82.—Crude diagram of contact areas and inflammatory zones following compression ultraviolet exposures over incisors. Note overlap of inflammatory zones in region of apex. These three contact compression exposures are made on both buccal and lingual surfaces, making six contacts for a single tooth, ten for two teeth, etc.

A. Contact areas where end of quartz rod rests. B. Gum margin. C. Incisors. D. Extension of inflammatory zone after treatment.

reason that you would not adrenalize them—interference with prompt formation of vigorous reaction. If the applicator is plated or metal covered you can steady it as well as make more pressure with less strain upon the rod by holding the lamp in one hand and using a finger of the other hand laid alongside the rod. If it is not covered then you will have to protect it in some way as otherwise the patient's lips or tongue will be blistered from lying against it in repeated applications to the small area to be covered. In covering these quartz rods some nonabsorbent

material should be used. Plain adhesive is very much absorbent and will reduce the quantity of rays reaching the distal end of the rod very materially. Bright, smooth tin foil cut into long strips, wound around the quartz rod smoothed down and then covered with adhesive offers a surface to the rod that not only is not absorbent but reflects the rays striking it, but the covering of these rods for each separate patient is a bother and a shorter way is to send the quartz rods in to the maker for plating.

This tissue reaction is—if violent enough—not only effective in clearing up the area of germs but is a decided stimulant to new bone formation. Repeatedly I have treated teeth where the absorption was so great that the tooth could be moved freely from side to side simply from the pressure of a finger tip and a year or so later, upon examination, find them as solid as any normal tooth should be. Upon my stating this fact to a class in the City of Boston recently, one of the doctors asked whether I was prepared to state from any direct examination of any of these treated cases that new bone *actually had formed.* I was compelled to admit that, although clinical evidence and repeated x-rays indicated such facts, I never had actually cut down onto such areas to prove the fact visually. A Doctor O., a Boston physician in the class, who had been doing much x-ray and ultraviolet ray work, volunteered the information that the ultraviolet method of treating pyorrhea had been in use in a clinic that he was connected with for about two years and that they had noted this fact, but in spite of its apparent truth and confirmatory x-ray findings the argument finally had reached such stages that only the actual demonstration of the presence of new bone would settle it and they had cut into some of these areas and found that the bone absorption area had actually filled in with new bone. This tightening up of the affected teeth is such a constant result of the treatment that its absence would be taken by me as an evidence of too mild reactions having been produced at the original treatment and I would repeat the treatment with larger dosage.

I have never been able to produce any such results until the much improved lamps of some two or more years ago appeared

and not then by the use of the usual air-filled quartz-tipped applicators. The very short wave lengths necessary to produce these very stimulating reactions cannot be obtained from any of the lamps made prior to that time and cannot be *delivered into the tissues* (the only place where they are of value) from a modern lamp through an air filled applicator even though it be quartz tipped. The air acts as a perfect filter, absorbing or refracting them and they do not get through.

I am going to give only one illustrative case although I could repeat many. This case was a bad one, a patient officer in the Fox Hills Hospital (now closed and dismantled), Major ———. He came into the clinic one warm spring day, wearing a natural sheep wool collar turned up around his face and a silk kerchief folded and tied over one side of his face, suffering from an acute attack of trifacial neuralgia. I found that he had been having treatment for two years for a bad pyorrhea of the right lower canine, bicuspids and first molar and the right upper canine and first bicuspid. The neuralgia had struck him more or less severely at intervals for the last year, but had never been so acute as the present attack. He had made up his mind to secure relief from the present attack and then have every one of the affected teeth extracted and came into our clinic for treatment for his neuralgia and not for his teeth. The dental section did not hesitate to tell us that we were away out of our depth when we asked their permission to treat the pyorrhea, but said to go ahead and they would follow the case with interest. They did not follow the case very long as the first treatment (covering the whole area, as he expressed a desire to die or recover all at once) resulted in his sleeping all night the following night and outside of a terribly swollen face and a few spiteful stabs of pain—not the acute, prolonged paroxysms that he had been having—at rapidly lengthening intervals his recovery was uneventful. I might state that he received an ionizing dose of x-ray and thirty minutes of radiant light and heat from the 1500 watt lamp over the affected side of the face at the first treatment in addition to his pyorrhea treatment and that he later received diathermia and the static condenser discharge over the trifacial area

to help clear up the infective neuritis. All of the affected teeth were loosened by absorption and three of them were apparently only hanging by slight attachments. He received several subsequent diathermia and static treatments, a second dose of x-ray and, upon his own request, the ultraviolet to the gums was repeated six days after the first treatment. He was discharged a few days later and we forgot his case until one day, over a year afterwards, he walked into the office in civilian clothes and asked us whether we remembered him. We could not place him at first. He reached into his pocket, brought out one of those hard, three cornered Brazil nuts and cracked it between the teeth on the right side of his face and remarked, "Well, now, if I were to put on a Major's uniform, a sheep skin wool-lined collar, tie my face up in a silk handkerchief and make a mournful noise like a resined string being pulled through a hole in the bottom of a tin bucket, would you know me?" We went over to the dental and x-ray sections where there were still on duty several of the officers who were familiar with his previous condition and had some x-rays taken. His case made quite an impression. The fact that he could and did crack nuts on those teeth that I would not have attempted to crack with my best teeth shows their solidity better than any description could.

The quartz rod pyorrhea applicator should not have a perfectly square end with sharp edges as these edges are painful under pressure and might cut the gums severely if the patient were to move the head suddenly or the operator's arm tire and cause the rod to slip. The sharp edge at least should be ground off. At least the angle of the quartz rod, where most of the last rays leave it if unplated or uncovered, should be silver or nickel plated or covered with bright tin foil.

Remember that one *real* heavy *tissue reaction* is worth more than a score of lighter ones which might sterilize the surface of the area but would not be stimulant enough to initiate bone repair. Above all, do not condemn the method as inefficient until you have produced this proper reaction upon several cases and watched them for a year or more afterwards. I know exactly what your reaction will be *then*.

I have not gone into the treatment of the various stages, as if a given case is deemed a proper one for conservative treatment the stage would not make any difference in the attack. If I found the slightest evidence of infection around the gingival margin of any tooth I would treat it just as thoroughly as one showing x-ray evidence of extension all the way to the apex. This is the only safe method. I do not advocate the use of ultraviolet for the treatment of apical abscess as *if pus is really present in a mass* of any size then only the outside edges would be sterilized but abscess formation may very often be arrested if treatment is applied during the formative stage. Pus itself has no power of reaction, being dead tissue, and is opaque to ultraviolet light and it is only where it is present in small quantities that the surrounding tissue reaction is intense enough to sterilize it. It is equally obvious that any treatment would be incomplete which treated the outside of a tooth and left an infective canal to re-infect the apex at a later date. It is assumed that all necessary root canal sterilization and filling has been or will be done where indicated concurrently with or ahead of the treatment of the external surfaces.

CHAPTER XXIII

GENITOURINARY CONDITIONS

It is against my policy to list a number of conditions and then prescribe for each of them. Much better, in my estimation, to list the physical remedies, give their reactions and allow the physician to do his own prescribing, giving just enough illustrations to make points plain. There are a number of genitourinary conditions that are more or less refractory to ordinary treatments that are handled very quickly and positively with physical remedies and I think a summing up of some of the more common of these would possibly suggest new treatment methods sooner than if the physician were left to work them out after considerable experience along other lines.

Acute Cystitis, Prostatitis, Vaginitis, etc.—Conversive heat, one electrode in rectum and the other over pubis as in gonorrheal arthritis. Sedative technic, five to seven or eight hundred milliamperes (the larger the curved metal electrode used the larger the milliamperage that can be used). Ultraviolet light locally through rectum and vagina in cystitis of female and through rectum in male, general ultraviolet for its general tonic effect. In prostatitis the addition of the static condenser discharge is very valuable but used alone will do little good. The more chronic the "itis" in the prostate, the more necessary it is to add to the conversive heat ionizing doses of x-ray; some modality such as the static condenser discharge, the Morse sine wave, the slow sinusoidal, etc., to produce a massage effect. The static condenser can be used in acute cases following the diathermia and the improvement in some of the very worst cases after one day's treatment with the two, plus ultraviolet will never be credited until seen several times. The rapidity with which the acute symptoms subside often surprises an experienced user of physical remedies. On July 11, 1922, I had a very fine illustration of this. I received a telegram that my father—practicing

physician over sixty years old—was very dangerously ill with an acute cystitis and prostatitis and was to be operated the following day. I made the run out there in about thirty-six hours and found him with a high temperature, having chills, under opiates in the form of rectal suppositories and being catheterized every few hours. It seems he had been having more or less trouble with a chronic prostate for about seven years although he had never complained to me of it, and I was unaware of his condition. Starting at that time he began to have an irritation of the bladder which necessitated his getting up some time in the night to empty the bladder. This gradually increased so that a couple of years later he was getting up twice and noticing some trouble during the day when at work. This increased slowly but steadily and in the last year he had had to lay off work for a few days at various times and keep off his feet to rest. Some seven weeks before this date he was sixteen or more miles out in the country when a sudden rain soaked him and he rode home in an auto in his wet clothes and on the wet cushions. The chilling resulted in a cystitis which was relieved under drug treatment and rest but which recurred each time he got up and attempted to return to work. This went on for some weeks until it flared up very acutely, the urine became milky with pus, later blood appeared, his temperature shot up, strangury and pain became so great that anodyne suppositories were used and catheterization was started. When he became worse instead of better under irrigations and all other treatment the three stage prostatectomy operation was advised, the prognosis being unfavorable on account of his condition. When I consulted with the surgeon (who was for immediate operation as offering *the only chance*) he did not like my proposed treatment nor did I like what he proposed. When we decided to compromise by following out my own physiotherapy treatment, he assured me that I was assuming an awful responsibility in refusing operation, but agreed that if I had anything whatever that would benefit a man in my father's condition that it was something a little better than surgery in this case. To make a long story short I gave him *one* diathermia treatment (rectum—suprapubes) and let him rest a few hours. He slept soundly

(without any opium suppository) for six hours and forty minutes following the first treatment which was a very much longer time than he would sleep after a suppository and catheterization. The suppository usually allowed him to sleep a couple of hours and to obtain partial relief a couple of hours longer. After the second treatment he slept eight hours and his temperature began to fall. At the end of three days he was slipping out of bed and to the phone or down stairs every time we turned our backs (this is about *average obedience* we may expect from physician patients) and was emptying his bladder most of the time without a catheter. The urine was clearing up *markedly*. He kept improving so fast that I went to the country to visit a friend one night and the next day being Saturday (six days after he started his treatment) and a big office day he prevailed upon the family to allow him to go to the office and he worked eight hours before we could get to him and stop him off. I expected another flareup but he came up smiling the next day without a single symptom of bladder irritation, refused to stay in bed, and tried to convince me that he needed a long auto ride. He went back on regular office hours the following week and has been there continuously for six months. After his first treatment I added rectal ultraviolet light and after the third the static condenser discharge to the prostate per rectum. After he became able to go down town I started him on ionizing x-ray dosages. He took treatment regularly for about two weeks and subsequently (after I left) catch as catch can. I expected to be able to control both his cystitis and prostatitis in the course of time but we would have been satisfied to have had him make the progress in a week that he made the first day and in a month or six weeks that he made in six days. I have seen such results before but in younger men without the chronic prostate history. I cannot but believe that the use of that most sedative of all remedies—conversive heat—is much better therapy than a resort to anodynes and catheters in such conditions as this and in many other conditions.

In *acute* epididymitis or orchitis one conversive heat treatment is often sufficient to stop all pain and cause swelling to subside. Where the process has gone for several days before

the application the results are slower but just as sure. Scar tissue is minimized in any event and prevented where the treatment is used early. The patient should be kept off his feet, a support for the scrotum made by placing a wide strip of adhesive across the top of one thigh dipping down under the scrotum and up over the opposite thigh, thus making a suspension bridge for it to rest upon. When time for treatment comes a small, spoon-bowl shaped piece of crookes metal or other flexible metal is cut to size, moulded so that it makes good contact, soaped, laid upon cotton or gauze to support it, the scrotum soaped and laid onto it and one cord from the diathermia circuit attached. The other electrode is applied to the top of the scrotum in similar manner, care being taken that the epididymis is included in the heat path between the two electrodes. Dosage according to size of electrodes but the density of current rule—not over 1000 milliamperes to 16 square inches—may be more than doubled with safety here if coaptation of skin and electrode is perfect. Treatments should be given daily for ten days or more no matter how rapid improvement results from the first treatment. If attempt is to be made to break up scar tissue then diathermia, ionizing, x-ray (this small dose is harmless to testes) and massage up to tolerance should be instituted and followed up for some weeks.

Urethritis.—The use of conversive heat in urethritis has been covered elsewhere and will not be repeated here.

Urethral Stricture.—More failures, probably, have been scored by physicians trying to do Newmann's negative galvanic technic than any other one procedure. The technic is so simple that it is hard. It is so absolutely effective (when done in a manner to make it effective) that all other methods of treating annular stricture look very pale by comparison. The technic is so simple that it never has been perfectly correctly given. The best discussion of the technic by a master in the use of galvanism contains one vital error. He ridicules (and quite properly) certain physicians for attempting to do the work without a meter to measure the milliamperage and others for using dosages so large that they make the condition much worse and then goes on to make the same error on a smaller scale when he states that the correct dosage is "five milliamperes."

A *certain density of current* will give effects where the solvent action of the negative current will overbalance the irritant effect of the same polarity. Increase this density of current only very slightly and the irritant effect will overbalance the solvent effect and the tissue reaction (kick-back) will result in the subsequent formation of more scar tissue than was removed at the treatment and the oftener the treatment is repeated the worse the local pathology becomes. Diminish this density of current only very slightly and it is not strong enough to soften and break down the scar tissue. This very narrow efficiency limit is the answer to its great percentage of failures.

What is density of current? It is the number of units of electricity being delivered through a given unit of area—in other words, the number of milliamperes per square centimeter, per square inch, etc.

When this treatment is given properly the olive tipped electrode does not *go through* the stricture when it is first inserted; it goes up to and engages in the contracted ring. The face of the olive tipped bougie is bevelled so that the area of contact is almost the same shape as the contact area between an automobile engine valve and its seat. The larger the caliber of the stricture the wider will be this strip of tissue bearing upon the electrode and receiving the current. Thus, doubling the diameter of the electrode a great deal more than doubles the active area or vice versa. Thus, if five milliamperes is the proper density for, say, a size 28 F. bougie then it certainly is many times too great a density for use on a size 12 F. and if it is a proper density for size 12 F. then it certainly is going to be far too weak to do any good when scattered out over the large area of a 28 F. electrode So that if five milliamperes is to be the dosage in all cases then most of them will fail, for the proper density of current will only be reached on those strictures of a certain calibration. All larger and smaller strictures will receive either too little or too much current.

The proper dosage ranges from a milliampere or slightly more for a size 10 or 12 F. to about six milliamperes for a size 30 F.

The technic is to calibrate the stricture, *using no force* beyond a few ounces pressure applied to the end of the bougie staff

(the same staff and olives used for treatment make the best possible calibration set) with a single finger. Steel sounds should not be used as it is extremely difficult to calibrate even approximately correct with them on account of their various shapes, some being blunt but many tapering gradually from the curve to the point and it is much too easy to use too much force. When the olive comes into contact with the stricture the staff should be held lightly between the thumb and middle finger and a very light but steady pressure applied for a few seconds with the forefinger to the end of the staff. Keep trying until a size is found that will just slip through the stricture when used in this manner and then choose a metal olive just two sizes F. larger than this one and insert down against the stricture. Attach cord from negative pole of galvanic current, positive going to a moist electrode under buttocks or back. Turn on current very gradually up to the proper density, support the penis with fingers of left hand, apply light pressure as above with right hand and allow current to flow until the olive slips through stricture. This time will average around five to six minutes, sometimes a little longer in large strictures and often less in small ones. When the metallic olive has slipped through the stricture reach around and slowly turn the rheostat back to zero and then withdraw the staff and olive gently. No forcible, sudden pull should be used. Blood, except in the most irritable urethras, is an evidence of trauma and shows the use of too rough methods in instrumentation. Treatments may be repeated not oftener than every four or five days—the latter preferred—using a metal olive two sizes F. larger at each succeeding treatment. Injections, nonvacuum heat, etc., may be used to allay irritation if the treatments have to be crowded closer together, but it is very much better to allow five or six days between treatments if possible.

Used with this technic there will be very little irritation and practically no failures. I have removed as many as five strictures from a single urethra, treating each one each time after I had opened up the ones nearest the meatus to a larger caliber than the deeper ones. I have examined a few of these cases fourteen years after the treatment and find no evidence of any narrowing of the urethra at the original point of stricture.

CHAPTER XXIV

HAY FEVER

The treatment of hay fever by physical means comes near to being specific. The treatment is divided into three steps: first, nonvacuum high frequency; second, ultraviolet ray to the anterior nares; and third, ultraviolet ray to the posterior nares and nasopharynx.

First Step.—Have the mucous membrane clean. Attach a nasal nonvacuum high frequency electrode to the Tesla or Oudin terminal of a good high frequency outfit, regulate the spark gap so that a very mild heat is delivered. This can be determined by holding the flat side of the electrode against the operator's hand and slowly moving it away from the hand. The current should be just strong enough so that when contact is broken between the electrode and the operator's hand a *very fine* effluve is visible but not enough current to produce heavy sparks. Very gently insert this electrode into one side of the nose, turn on the current and thoroughly and *slowly* iron out the mucous membrane. Hold the electrode in one spot for a half minute or so and gently slide it to a new position and repeat. If the electrode is lifted off the mucosa a spark may result which, while not in the least dangerous, will startle the patient, annoy him and set him to sneezing. Cover every accessible bit of nasal mucosa in both sides of the nose with the gentle heat. Then remove the electrode from the nose, open the spark gap until an effluve or shower of fine sparks about an eighth of an inch in length will jump to your hand. (If you know your machine well enough to make the current increase without removing the electrode this is better technic—simply turn on a little more current by opening the spark gap without taking the electrode out of the nose.) Cut off the current, insert the electrode, turn on the current again and, as before, cover the whole mucosa with this increased current. Considerable heat is now being formed and the patient's

tolerance may not allow you to hold the electrode in one spot for more than a few seconds. If so, keep the electrode slowly moving and cover the area oftener. Cut off current, remove electrode from nose, and again increase spark gap and proceed as before, remembering that the heat is now more intense and the exposure time of any given unit area must be shortened. Be guided by the tolerance of your patient. Give about ten minutes of this local high frequency to each side of the nose and then lay the high frequency aside and proceed to the second step in the treatment.

Second Step.—Attach the quartz nasal applicator to the ultraviolet lamp, insert the applicator as far back in the nose as possible and expose for about one minute. Then withdraw the applicator a half to three-quarters of an inch and give another minute exposure and repeat until the whole of the one side has been rayed. Do the same for the other side. Most of the ultraviolet ray is transmitted through the quartz to the end of the applicator and if the end be placed in contact with a given spot on the mucous membrane and held there for more than a minute a blister will result. Some lamps will blister with this nasal applicator in anything more than half a minute's exposure on one spot if the end of the applicator be *pressed* against the mucosa, but not if it is lying on or between folds of membrane. No particular harm would be done except that it is not necessary to blister to secure best results. By withdrawing the applicator a fraction of an inch each time the blistering is avoided. When both sides have been rayed, lay aside the nasal applicator and give the last stage of the treatment.

Third Step.—The last step consists in the raying of the posterior nares, nasopharynx, etc., with the ultraviolet. We have designed a special quartz applicator to be used for this purpose which, properly made from crystal clear quartz, will deliver more ultraviolet to the posterior nares than any other, but in the absence of this special applicator good results can be secured by using the Baldwin laryngoscopic applicator. This can be used by turning it upside down so as to reflect the rays up into the posterior nares instead of down into the larynx. The objec-

tion to this applicator is that the rays are reflected up at right angles and that they are very much diffused making it necessary to give eight or ten minutes exposure instead of two to four as with the special applicator. In the special applicator the fused quartz has been shaped so that the rays are thrown upward and forward at just about the proper angle to get most of them into the posterior nares. When this special applicator is used the rays emitted are more concentrated and, in order to get an even exposure of all the area the lamp should be tilted *very slowly* for an inch or so to each side of the vertical and back, thus spraying the whole mucosa with the concentrated light which is better than a longer exposure of a more diffuse and weaker character. After the posterior nares have been irradiated it is well to remove this special applicator, put on a throat or tonsil applicator or simply a hollow metal tube and spray the pharynx and tonsils for a minute or so.

It does no harm—in fact, in many cases it is absolutely necessary—to spray or nebulize a weak cocaine solution over the *uvula* (but not over the whole mucosa). This, if allowed a few minutes to take effect, obviates much gagging and coughing and makes the posterior nasal treatment easier. For hygienic reasons it is well for the operator to put on a "flu" mask which need be no more than a square of sterile gauze tied over the nose and mouth to prevent flying particles of secretions from striking or being drawn into his own air passages.

For many years I had been treating hay fever and rhinitis cases with a high frequency glass vacuum electrode with indifferent success. Some cases responded nicely and others not at all, some even seeming to be aggravated. Then I hitched the glass vacuum electrode to the static machine and secured a more pronounced effect. When the nonvacuum electrode came out I immediately tried it out on these cases with a very marked gain in the percentage of cases relieved but was not yet satisfied. In the summer and fall of 1919 I conceived the idea of carrying the local action produced by the nonvacuum electrode (indirect diathermia) much further by superimposing a slight erythema dose of ultraviolet upon the mucosa treated by the indirect diathermia. The results can be characterized by no less a term

than that they were startling. No other procedures used by me came so near to being specific. I have space to cite only one case, but this case was the worst I had ever seen.

The patient's history was as follows: Male, age forty-six. Occupation, principal of a high school. History of previous attacks: Had been having hay fever regularly for eighteen years, the attacks becoming progressively more severe each year. Had been having asthma for nine years during the hay fever season and had been unable to sleep in a recumbent position for the last eight years during the same season. For six years has had to avoid the slightest draft and never thought of turning out the light at night until he had placed some half dozen special asthma candles and matches where he could reach them quickly when the paroxysms came on. To use his own words the tortures he underwent through the hay fever season made him seriously consider whether it was worth while to prolong his life until the next season would start the agony again. All previous treatment had been unavailing (he had been typed and treated) and it was with difficulty that I persuaded him to take his first treatment. He slept soundly in a recumbent position without awakening through the first night after. His wife went to his room at six thirty to awaken him and was astonished to find that a French window had blown open during a severe rainstorm in the night and that neither the heavy thunder nor the draft had disturbed his sleep. He took treatments daily for two weeks with complete relief almost from the first treatment. I now had difficulty in persuading him to stop his treatments as he was afraid of a recurrence. I instructed him to report to our clinic two weeks before his next hay fever season was due to start for a prophylactic course of treatment but, on account of his being away on his annual leave at the time, he failed to do so. He came in a couple of days after his attack started but it was a *very* mild attack as compared to those he had been used to having and he was not having the usual asthma. Five daily treatments were given him this second year with quick relief and the third year he failed to report at all during the hay fever season and inquiry developed that his symptoms were not severe enough to cause him to report for treatment.

I treated fourteen cases of varying degrees of severity in the season of 1919 and more in 1920 and another series in 1921. The result, so far, has always been the same: Marked relief from the first treatment followed by a quick clearing up of the condition within a few days. The attacks seem to recur at the succeeding season, but in a very much less severe form and are easily controlled. I believe that could the patient be persuaded to report some ten days or two weeks before the date of onset (they nearly always can tell the day of the month upon which their symptoms will appear) and receive some prophylactic treatments, in a large proportion of cases, the attack could be prevented entirely. If not, the treatment would result at the very least, in reducing the severity of the attack to a minimum.

Note: Since writing this chapter I have had an opportunity to try the prophylactic treatment on a case. The case was one of nine years' duration, severe asthmatic attacks accompanying the hay fever for the last five years. This case had failed to respond to typing and subsequent serum injections. The man, middle aged, was manager of a large instrument house in a city where I was delivering a course of lectures. The first treatment was given seventeen days before the date upon which the attack always started. Because of rush of business and one reason or another he did not report on the third day (treatments were to have been given on alternate days) and did not come in again until the eighth day. He reported on the tenth day and then not until the fifteenth day. When he came in on the fifteenth day he was suffering from a slight attack of hay fever. The irregularity of attendance nullified the chance of preventing the attack—in fact precipitated the attack five days before the time for it to appear. A treatment relieved him almost totally. I had to leave at this point and left him to treat himself with instruments his house carried in stock. I had a letter from him in November saying that his hay fever this year had been so slight as not to disable him at all and much of the time so slight that he almost forgot that he had it and that he had not had any traces of the terrible asthma at any time—in fact that this year's attack was much the mildest he had ever had.

CHAPTER XXV

TROUBLE SHOOTING

Nothing is quite so helpless as the average doctor when something goes wrong with an outfit he is using and it ceases to work or works very erratically. Ninety-nine times out of a hundred the trouble is a very minor one and is easily remedied on the spot. In the early days of the automobile when it was not nearly so efficient as at present, I can well remember when it was a cause for celebration when a car could be driven a few miles into the country and back without trouble or without having to be towed to a man who could locate the trouble. Now nothing much short of a mechanical break of a part will stop a car for more than a few minutes and many owners drive years without ever having a tow rope fastened to their car. They are quite capable of locating trouble and remedying it themselves. They do not give up and call for an expert the moment anything happens. The same ought to be and in the course of time will be true of electromedical apparatus.

When an automobile that has been running smoothly stops dead, the motor-wise driver immediately, and before starting to tear up the engine, inspects his gasoline supply. If he has gasoline in the tank he goes to the carburetor and sees whether the supply is being *delivered* there and if not goes back along the supply line, through the Stewart feed system, etc., until he locates the point of obstruction and removes it. When an outfit that has been operating *perfectly* suddenly stops the chances are that the current is cut off. This may be due to a break outside the office or at the power house or it may be a blown fuse or a broken connection along the path of the current creating an open circuit. If all the lights in the office go out at the same time the outfit goes dead it is certain that either one of the main fuses has blown out or that the outside power has been cut off. The first thing to do, however, is to open the main switch on the outfit and disconnect the patient so that he will not receive a

shock when the power is again turned into the circuit. Inquiry or the turning on of a light in a neighboring office upon another fuse circuit will tell whether the building current is off or, at night, hall lights will show this. If power is off in other offices, then it is a case of calling the supply company and finding out whether the power is off generally or if it is a local transformer fuse blowout, etc., and, if so, having them send a trouble man to repair the open circuit. If the power is not off in other places in the building then it is your own circuit. Every man using electrical appliances should know just where *his* fuse box is and what size and shape fuses are used in it and have a reserve supply of fuses to replace a burned out one. These fuses should be kept in a place where you can easily *put your hands upon them in the dark.* Never allow any one to move them around. They are prone to disappear if you try to keep them in the fuse box if it is *outside* your offices. A piece of tallow candle in the fuse box helps if the fuse box is in a dark place as a flash light is often out of pocket, dead, broken, etc., just when most needed. Turn on one or two lights so that you can see them light up when the current comes on. Take a couple of good fuses of the right size and go to the fuse box or panel. Pull or unscrew one of the main fuses and substitute one of the good ones. If this causes the lights to come on then the removed fuse is the burnt out one. If not, then remove the other main fuse and insert the one you have just removed from the other socket. If this brings on the light then the last fuse removed was the burnt out one. If this does not bring on the lights, remove the last fuse inserted and replace it with the other spare fuse you brought out with you. This latter procedure will only be necessary in the rare event that *both* fuses were melted at the same time. If you get the good and burned out fuses mixed you can separate the good ones from the bad by removing one of the good ones after the lights are on and trying the others in its socket one at a time. The good ones will light the lights and the bad ones will leave them dark. Never put the burned out fuses with the reserve supply of good ones as it will throw you off every time you have trouble. If the burned out fuses are nonrenewable throw them away. If it is of the refillable type then *refill it* or put it in a

box marked "dead fuses" until several collect when you can refill them all at one time.

If the office is supplied by several different circuits from a fuse or panel box the chances are that the main fuses will not be melted but that one or, very rarely, both of the fuses on that branch circuit are out. If this is the case, lights on *other circuits* in the office will continue to burn after the circuit in use has gone out. If this is the case you can tell whether the fuse is blown simply by removing the cable leading to the outfit from the socket and inserting a bulb from one of the lighted circuit into the socket. If it lights up then the trouble is not a blown fuse, but is in the removed cord or the outfit itself. If it does not light up (be sure that the bulb itself is not burned out) then go to the fuse for that branch circuit and proceed as before. Where many sets of fuses are in a panel box it is well to number each pair of fuses and to paste a list of the sockets or outfits pulling from each number on the inside of the panel box door where it will always be available. This will save much time that would otherwise be lost testing around over the whole layout each time a fuse blows. Be *very slow* to overfuse a circuit as a fuse is a safety device and if oversized may allow an unsafe amount of current to enter the circuit. If fuses are repeatedly blowing on a given circuit hunt the cause down and remedy it rather than try to save trouble by oversizing the fuses. A short circuit on a normal sized fuse will melt the fuse before the circuit has time to get hot enough to start a fire and usually before the outfit has time to burn itself out, but if the fuses are oversize this element of safety is removed. If the fuses are not blowing from a short circuit but from an overload by having too many or too large outfits pulling from it there is all the more reason for not oversizing the fuses. Larger wiring is needed before larger fuses are inserted.

A trouble lamp should be a part of the equipment of any one using electrical appliances. This is simply a rubber or porcelain *insulated* socket with a good incandescent bulb in it and the wires leading into it cut off a foot or more from the socket. The insulation on these wires should be of good quality and a half inch or so of the end of the wires should be bare and scraped

free of all insulation and the points kept bright. It is well to run a few turns of insulating friction tape over the insulation for an inch or so back from the bared tips as this is where the tester holds the wires when applying the tips to the test circuits and not only gives additional protection from short circuit to your hands but keeps you from carelessly getting your fingers *past* the end of the insulation onto the bare wires. This test lamp costs but a few cents and is invaluable in testing fuse blocks, sockets, conducting cords, etc. One thing should always be remembered when using it. If it is filled with a 110 volt bulb the bulb will burn out almost instantly or explode if placed across a 220 volt circuit. Where a panel box has three bus bars (the main copper feed bars from which the current is taken to the fuses and circuits) the lamp should never be placed across the two *outside* bars as this will give 220 volts. Place one tip on the *central* bar and the other on one of the outside bars if you are testing the supply of the board. If the lamp bulb in the testing socket is a 220 volt bulb then it will be safe to test across the two outside bars. To test a given pair of fuses with this test lamp, place the tip of one wire onto the connection of the circuit to the binding post or screw where the wire from the circuit comes to the fuses and the other tip onto the other screw where the other wire of the circuit is fastened to the fuse block. These tips must be placed upon *bare wire* or upon the metal screw head holding the wire to the fuse block and to be of any value the lamp must cross the circuit *outside* the fuses. That is, it must be applied across the circuit where it *leaves the fuses* for the office and not across the circuit where it enters the fuses. If the lamp, so applied, lights up, neither of the pair of fuses being tested is dead but if it were applied across *inside* the fuse block then it would light even if one or both the fuses were dead. If it fails to light when placed across the circuit *outside* the fuse block then it is only the work of a second to tell which fuse is dead or whether both are dead. Place one of the test bulb tips *inside* the *top* fuse and *outside* the *bottom* fuse. If it lights it proves that the bottom fuse is good as the current must *go through this fuse* to get to the outside leg of the circuit. Then place one of the test tips on the *outside* of the

top fuse and the other on the *inside* of the bottom fuse. If it lights the *top* fuse is O. K. If the lamp does not light *either* way then *both* fuses are dead and should be replaced. This is a much quicker way of testing fuses than to remove each one separately and insert new ones and if the office is remote from the fuse blocks saves calling back and forth to see whether the current is on.

Assuming that the fuses are all good, if a bulb inserted in the supply socket fails to light up then the *socket* is burnt out or broken. A binding screw where the circuit wires are fastened to the fuse blocks might be loose. The chance of a broken circuit between the fuse block and the socket (other than this loose end) is so remote that it need not be considered. Countless sockets are ruined by screwing bulbs or socket plugs into them too tightly. Most of these sockets are made with a piece of spring brass in the center to make the central contact while the other is made by the metal shell of the socket. A bulb or socket plug should not be screwed into a socket so firmly that a pipe wrench would not move them further as this crushes this brass spring clear down and repeated often enough breaks it off or partly off where it can move around and touch the shell and cause a short circuit. Even if it does not break, some socket plugs are faultily made in that their outside metal shell extends too far towards the tip and when such a plug is screwed too far into a socket the distance between this metal shell and the brass spring is lessened to such an extent that arcing of the current occurs. A light bulb or a socket plug should be screwed into a socket until contact occurs (proved by lighting in the case of the bulb or action in an outfit) and then turned only part of a turn further—say a third or a half turn. A little attention to this detail will save many burned out or broken sockets.

Assume that the socket is all right or has been repaired if faulty and that the outfit does not work. Following the source of supply of the current the next thing is the connecting cord between the socket and the outfit. Here again a trouble lamp will save lots of time. Screw the socket plug of the connecting cord into the socket and have an assistant hold the end that normally goes onto the outfit. Make a connection across the

two studs or socket holes in this plug or across the two rings if it ends in a pair of copper rings to be fastened onto binding posts on the outfit. (In handling two loose ends of wire *connected up* to a current supply keep them away from *each other and any other metal and keep away from them yourself.*) If your trouble lamp lights up then the conducting cord is all right. If not (always be sure that you have a good *metal to metal* connection between your test tips and the connections in the plug) then the trouble is in the cord. In the absence of a trouble lamp the substitution of a new or good connection cord may prove that the old one has an open circuit in it somewhere. Assuming that the cord has been found faulty the trouble is almost always *inside* the end plugs (loose connection, connection broken off, etc.) or in the first inch of wire just outside these plugs where the wire is bent sharply every time the cord is moved. A loose or broken wire at the screw where it is connected to the plug is easily found and remedied. If the wire is not broken, simply tighten up the screw holding it. If it is it will be necessary to *remove the cord from the supply socket,* (never try to *work* on *any* cord attached to a *live* socket unless you crave excitement) loosen the other wire from its screw, cut them off evenly, peel enough insulation from each to allow the bright, clean bare wire to be looped around the screw and fasten each wire to its screw in the plug by screwing the screw up firmly. If the break is inside the insulation, it is a little harder to locate, but as it is almost always right at one or the other plug this should not stump you for long. If the break is at some other point along the cord there are always indications of its location. The cord may have been crushed on the floor by having some heavy apparatus rolled over it when of course it shows the damage. It may have been jerked taut some time with a kink in it by a moving of its outfit without disconnecting it. Running a finger down the cord will usually detect a bump at this place where the wire that was bent but not broken still retains its bend or where the insulation was damaged by the sudden bend and strain. A smell of burnt insulation may be apparent where current arcs cross between the two broken ends or from one end through the insulation to the other wire. This arc may be heard or even seen at times.

If the break is inside the insulation near one of the plugs it can be found by loosening up and removing both wires from the plug and holding the cord firmly in one hand, applying a pull with a pair of pliers to first one and then the other of the bare ends of the wires. The broken one will give at each tug or come away.

Having traced the current down to the outfit and assuming the outfit still refuses to work, the procedure from here on will vary with the type of outfit. Practically all low tension outfits have either a series lamp or a series resistance in the circuit. If a lamp it will be on the front or top of the wall plate or table and if a resistance unit it will usually be found on the back or under side. If a lamp, the bulb may be burned out; vibration or some one fooling around the outfit may have partially unscrewed it so that the circuit has been opened or if there is a thumb switch on the base it may have been turned off at this point. As this lamp or resistance unit is a *series* resistance it is evident that if there is an open circuit in it at any point the board is not going to receive any current as long as this open circuit remains. If it is a resistance unit it may be tested with the trouble lamp, a magneto bell ringing test set or a telephone or wireless head piece with a couple of dry cells. To test with the lamp turn on the current to the board and trace the circuit to and through the resistance unit. Place one tip on the distal end of the resistance unit (the end most distant from where current enters the board or the end from which current goes *to the board* after it has passed through the unit) and the other tip of the test lamp upon the other leg of the circuit where it leaves the board or at some intermediate point by tracing it back and if the lamp lights (it may not light up fully as the resistance may allow less current to pass than the normal voltage of the lamp) and is steady the resistance is not open. If it does not light there may be a break in some of the turns on the unit itself or a soldered connection may be loose. If the unit itself is broken it should be replaced by a new one of the same size. (Get it from the maker.) If current is entering the apparatus but it is not working, then it is a matter of tracing it from connection to connection until you find the open circuit. Before

starting this tracing it is well to be sure that no switches on the front of the board are standing *open*. The polarity changing switch is *usually* the offender (?) when this happens. If it is a double throw switch see that it is closed. If it is a circular switch placed between the patient's conducting cord binding posts see that the words "negative" and "positive" are adjacent to these posts and not at the farthest possible point away. I have seen outfits the cause of much acrimonious correspondence and finally shipped long distances for repairs when the only thing that was wrong with them was that this switch was standing open.

If there are separate switches on the board for galvanic, faradic, sinusoidal, etc., be sure that you are not trying to use the galvanic current with the faradic switch closed and the galvanic switch open or vice versa.

A little oil on a bearing of a *constantly moving* part is a necessity. Oil *anywhere else* on a low tension outfit is decidedly out of place and may put the outfit out of *order*. Oil itself is an insulator but it catches dust, metallic filings or other material that will conduct current and causes short circuits between binding posts, turns of wire on a resistance coil or rheostat and may cause a burn out. Never allow excess oil applied to a motor or a bearing shaft of any kind to run down and spread over the board or get underneath where it will rot the insulation and cause trouble. I was once stumped for quite a while trying to locate trouble on a combination galvanic, faradic, and sinusoidal machine. Tests showed every wire on the outfit to be unbroken and each one in its proper place, firmly fastened, etc., and yet no current could be obtained from it. Finally I traced the current to the meter and there it stopped. "Open circuit in the meter" was the diagnosis. Meter was opened up and tested and was found all right in every particular. No open circuit there and current would pass through it freely while it was upon the bench, but the moment it was replaced upon the outfit it apparently would not let current through. I had examined the meter posts (solid metal and naturally conducted current when tested from top to bottom) and

had found that current could be sent all around the circuit when the meter was out and the two meter posts short circuited by laying a piece of metal across them. Here was an apparent mystery: a circuit that would conduct current with the meter out and the gap bridged, and a meter that would conduct current when it was out but when in place seemed to act as a bar to the passage of current. A little study revealed that the only possible solution was in the *connections where the meter joined the supports.* This was a meter made so that it could be tilted in such a manner that the face was vertical or horizontal or any angle in between. It was made to work snug so as to hold it in the position in which it had been placed and to make a good contact. Because it *could be moved* the doctor figured it needed oil and oiled the two shafts where they went from the meter into the upright supports. The oil formed an insulating film around the inside of the holes and the shaft and so cut off the current. When all the oil was cleaned out the outfit worked perfectly.

If the patient receives no current at first when you begin to turn on the control rheostat and suddenly gets a shock as you turn on more, then the chances are that the wire of the control rheostat is broken. When the traveling contact under the lever or knob crosses the break it picks up the current and so the shock. The loose end of the wire *might* fly around and rest against the moving contact and stick there. In this case your patient would receive a shock as soon as his conducting cord was attached to his second electrode and the circuit completed even though the control rheostat were setting upon zero.

If the break is in the resistance block wiring in the rotor on the sinusoidal or surging currents then there will be a ragged shock every time one of the revolving brushes crosses the break or strikes the free end of the wire. The break can be found by removing the metal cover and inspecting the wiring of the resistance blocks or coils. Another way the patient may receive regularly recurring shocks on the sinusoidal or surging currents even though the resistance wire *is not broken* is when one of the retaining screws holding the metal cover over this rotor (on

outfits having this metal cover) is screwed in so tightly that it springs the metal cover inward at that point so that the metal carrier arm for the brush strikes against it upon each revolution. Remember that a shock can only be caused by some make or break (or both) of current and figure it out. If it is in the straight galvanic line then suspect the control rheostat. If it is in the sinusoidal or any of the so-called wave currents and is recurrent then it is in some moving part—almost surely in the rotor. It might possibly be a broken conducting cord which makes a contact of the broken ends when some movement of the patient or operator *changes the position of the cord* or when a breeze strikes the cord and starts it to swaying. In this case the shock would only be occasional or would coincide with the sway of the cord and could thus be located.

If current is coming to the board but the patient is not receiving any, a quick way to tell whether the trouble is in the board or in the conducting cords or electrodes is to turn the rheostat *back to zero,* moisten the thumb and forefinger or middle finger of the left hand, place the thumb on one patient's binding post (the place where the cords leading to the patient are fastened to the board or table) and the finger upon the other patient's binding post and slowly turn on the rheostat until the meter registers the passage of current or until the current can be felt passing through the hand of the operator. The method of short circuiting the two binding posts with a metal screw driver, pocket knife or what not to tell whether the current is being delivered to the patient's binding posts is very bad practice. When this is done there is a dead short circuit *with no resistance* in it and the delicate milliammeter is almost certain to be burned out or very badly strained. If no current is detected by this test, then there is an open circuit somewhere in the line *back* of this point. If current is detected and the patient receives none when attached, then the break is *between* the binding posts and the patient. Several things can cause the patient to fail to receive the current which is delivered up to this point. The first and most usual thing is a broken conducting cord. The cheap tinsel and twine (nicely covered) conducting cords

almost universally furnished with galvanic, faradic and sinusoidal outfits are all right for use provided they are seldom ever used. They will not stand any degree of steady usage and my practice is to bury them in an active furnace as soon as I receive them to save trouble later. Finding it impossible to obtain *good* cords upon the market I laid in a large supply of removable tips and finely braided *copper* Coolidge tube control wire and made my own cords. The few minutes trouble spent in making a pair of cords was saved many times over in the avoidance of later trouble in the clinic. These cords break only after long and hard usage and are easily repaired when they do break.

When a conducting cord breaks, the break is nearly always at the point or near where the cord enters the metal tip. To test the cords the following procedure may be used *provided* it is done quickly and carefully: To test *both* cords have them attached to the outfit and hold one tip in the fingers of the left hand. With the other tip in the right hand fingers hold the tip an inch or so above the left tip and quickly bring it down past the left tip *just barely allowing it to touch* the other tip *as it goes by.* If they are laid slowly one upon the other or allowed to touch more than a bare instant the meter will suffer damage or be ruined. A safer but a slower way is to hold the right tip against the base of the thumb with the little and ring finger tips (having all fingers moistened) and touch the left tip with the right forefinger. This throws the resistance of a part of the hand and the forefinger into the circuit and prevents a dead short circuit. If current passes (indicated by a jump of the meter needle at contact) then *both* cords are all right. If no current passes then one or both cords are broken. To test the right cord alone simply drop the left cord and use the tip of the right cord or the forefinger with the tip held as described. Touch this to the *left* patient's binding post in the manner described (that is, quickly if metal touches metal). If the right cord is unbroken the meter needle will jump each time this is done. Then test the *left* cord using the tip or finger upon the *right* binding post.

If both cords are all right, then the break in the circuit is *beyond* the cords or in some part of the electrodes themselves. The constant twisting (especially if bevelled point tips and friction sockets on the electrode are used) incident to attaching the cords to the electrodes or stresses upon the attached cords from movements of patient, pushing against cords while lifting or adjusting the patient after the cords are in place on the attached electrodes, etc., often breaks the binding post on the electrode loose or breaks it and a piece of the metal back of the electrode off, the broken piece being held by the rubber or cloth backing of the electrode so that the break does not show and thus causes interference to passage of current. Another cause may be insufficient wetting of the composition of the electrode. It is not always sufficient to immerse composition electrodes *in* water to wet them. I have cut the rubber backing off of more than one such electrode after an all night immersion in water and have shown the metal back to be laying upon *dry* material. The water must be worked into and through these electrodes by rubbing and working them freely while in the water. Another cause may be that the movements of patient or operator while binding on the electrode may have caused a layer or two of a dry cloth or elastic bandage to slip underneath the electrode and between it and the skin thus causing an open circuit. The same thing holds if a cord tip be placed between layers of elastic bandage on top of a metal diathermia electrode so that a layer of rubber elastic is between the tip and the plate or cuff instead of being placed directly upon the metal plate or cuff.

Another mystery is present when tests show that all parts of the outfit are O. K. to and including the electrodes and when the rheostat is turned on a little ways an excessive amount of current registers upon the meter but the patient assures you that he is not receiving a bit of current. In this case some part of the patient's circuit may be touching a metal ground (metal in a table, pipes, etc.) or the electrodes may have been placed into position so wet that the excess fluid runs down the bandages or clothing to the other electrode and shorts the current *around* the part under treatment. I have seen all of these things happen

many times and have seen otherwise competent operators stumped for varying periods of time before they could locate trouble that was apparent after the most cursory glance or test.

Some high frequency outfits have a fuse block inside the cabinet and if the outfit suddenly ceases working and the socket and cord are O. K. this is the place to look for an open circuit. Some of the more elaborate galvanic, faradic and sinusoidal outfits have fuses also and I have known a needed outfit to stand idle for weeks while awaiting the visit of a trouble man simply because one of these fuses was blown. We have known an expensive trouble man to be sent a thousand miles to locate trouble in an x-ray outfit that had stumped the local dealer and his force and when he got there to find that a broken connection in a Coolidge control circuit *plug* was all that was the matter. This could have been fixed by the operator, the agent or any local electrician if they had known *how* to locate it and would have saved much delay, expense and exasperation. It is a habit of local electricians when called in to shoot trouble on any transformer outfit when they are unable to locate the trouble promptly to pass the much worn "buck" by locating the trouble inside the transformer tank (where, of course, they cannot be called upon to repair it) and many perfectly good transformers are shipped in to the factories when the trouble is a short circuit in the head of the trouble-shooter instead of in the transformer. Of course shorts in transformers do occur, but outside trouble should be eliminated or symptoms of trouble *in* the transformer should be so plain that there can be little doubt that that is the location of the trouble before the too common "transformer trouble" verdict is passed upon it. Some of these symptoms are —if it is an oil immersed transformer as most of them are— marked overheating, constant blowing of fuses where tests of outside circuits show absence of shorts, a very much shorter back-up spark than you know should result from a given set of the controls, a bubbling or dull popping when the spark shoots across in the oil or a rank smell of burnt insulation or scorched oil, etc. Every dollar needlessly spent in time, work, transportation, breakage in transit, etc., in these cases is inevitably added

to the cost of the business and makes the careful man pay a part of the cost of this needless overhead because the total cost of all these cases must be averaged and added to the other costs in figuring selling prices. As a rule the modern physical apparatus made by the American manufacturer is away ahead of anything else in existence in point of advanced design, ability to stand much abuse before going out of service and in the *quality* of output from the outfit.

One cause of trouble in an x-ray or high frequency outfit may be a shorting of two sections of the autotransformer control. Where the *active* metal contact points for the control lever are separated by a *dead* contact point (that is, an extra contact point inserted between each two active contact points which extra point is not connected to anything but is placed there to allow the lever to ride over from active button to active button easily and keep from interrupting the current) care should always be taken to set the spring contact under the autotransformer control handle *exactly* on the center of the *active button.* If it is set touching both an active and a neutral button or if it is set upon a neutral button the contact may be wide enough to allow the current to arc over from one active button through the contact to the next active button and short circuit the two windings with, of course, a burn out of the autotransformer sections or other trouble. If the active and neutral studs are of the same size the active ones should be plainly marked by arrows or other marks so that they are easily recognized and then care taken to center the contact upon the active button. Attention to this detail will save trouble and expense. The same thing holds for low tension outfits having a rotary selector switch for selecting the different modalities. The pointer under the knob may not be exactly true for *all* of the sets so that when it is centered over its mark it may throw the multiple point contact switch underneath the top of the outfit slightly over center and cause a short. This can be determined by starting of the outfit, selecting a modality, turning on the rheostat a little ways and placing the thumb and finger across the patient's binding posts. A little move of the knob controlling the pointer first one way and then

the other will show whether you have a good contact or not and how far to one side or other of the center mark you can move the pointer before contact is broken or before it shorts into the next set of contacts. And a word about allowing local electricians to tear down one of these multiple contact rotary selector switches. Any apprentice electrician can tear one of them down in a few minutes and he almost always thinks that he can reassemble it but the factory expert assembling them all the time works with a blue print constantly before him and even then often has to hunt out a misplaced wire and correct it. They very seldom give trouble and should not be tampered with unless *known* to be out of order and then they should be handled with a lot of respect.

In testing the back wiring of a wall plate or table it should be borne in mind that low tension currents require bright, clean and *bare* wire where the contact is made and the contact must be firm. The ends of the wires may be held firmly under the lock nut and washer and even then no contact made. The nut may be down tight, but if not enough insulation has been scraped from the contact end of the wire the insulation may stop the nut and washer when they are screwed down upon it and the bare end of the wire left in the air between the washer and the bottom contact or other wires below it with a break in the circuit resulting. If this happens in the low tension side of a high frequency of course no current passes but if it happens on the high tension side of the circuit the current will pass much as usual except that the gap which is bridged over by the high voltage acts exactly as an additional *open* spark gap and makes the current too rough for the successful giving of *sedative* treatments. Such an adventitious gap may be located by sound, sight or smell. Operating the machine with the cabinet open or even in the dark often shows it. A small mirror fastened to a long dry piece of wood is valuable for getting a view around and in behind places where it would not be safe to try to get your hand or head.

This brings to mind a caution about adjustments being made in a high tension circuit. When trouble has been located and

it is desired to repair it *never* trust the "on" and "off" lever or switch for keeping the circuit out of the outfit while you are tightening up connections, etc. *Remove the cable connection* to the outfit as well. Recently I saw an experienced factory trouble shooter get into trouble by neglecting this precaution. He threw the switch "off" and reached into the cabinet. The spot he wished to reach was a little farther than he had estimated and in reaching around some of the apparatus he lost his balance and with his free hand grasped at the top of the cabinet to save himself a nasty fall as his face was near some of the metal parts. He accidently pulled the lever to "on" and received a painful shock. It is not always enough to open a knife switch to a distance known to be safe for *low tension* current even if the switch is stiff enough to hold its position after being opened. I bear a couple of scars upon my right hand and a vivid memory of the brassy taste I carried in my mouth for some two days as a result of thinking that a low tension circuit was only a low tension circuit and therefore safe if a switch were opened a small fraction of an inch. One rainy afternoon I decided to tighten up a collar at the top of the left hand high tension terminal where it emerges from the transformer. The main knife switch was standing open as I determined by inspection. I took a metal pair of pliers and started the tightening up. To get more leverage I moved my hand back to the end of the plier so that one leg was held between the fore and middle finger, the thumb pressing against the other. I reached around (between the two high voltage terminals) and started to twist the collar down. At this instant a terrific flash of lightning occurred, struck somewhere outside, followed the lead-in wires to the switch, leaped across the small gap of the partially opened switch puncturing the air gap when the low voltage current immediately arched across and entered the transformer. The high voltage of the big transformer jumped from the terminal to the outside of my hand, through the hand to the pliers and through them to the other terminal. It was only a second or so until the fuse blew, but I learned more things in that second than in any other second in my existence.

The method of diagnosing and correcting trouble in an ultraviolet lamp outfit is given under the section on ultraviolet and will not be repeated here. The same thing holds for static trouble.

Most of the troubles one may be called upon to locate are easy to find and are usually due to short circuits or open circuits. A short circuit occurs when insulation breaks down, bare or poorly insulated wires are crossed or allowed to touch each other, metal objects are allowed to bridge across two contacts or wires, etc. I have seen Bristow coils fitted with new and tested dry cells one day and found them to be perfectly dead the next day when tests showed that all wires were perfectly insulated and no shorts *in* the outfit. The answer was found to be the practice of rolling the patient's conducting cords up and laying them on top of the instrument and closing the lid to keep them handy for the next treatment. One of the metal tips wedged or laid across the metal contact "on" and "off" buttons and ran the batteries down overnight. Keep *all metal objects*—no matter how small—off the tops and away from the working parts of your outfits and save blow-outs and run down batteries. Never turn current into an outfit until you *know* that connections are all properly made or, if for test purposes, until all cords are removed from it where they could cross or touch some ground and cause a short. Make it an invariable rule to look the whole thing over *just before* you turn the current on. Just after may be too late to save the outfit or save the patient a shock. Give your outfits a little care and attention, keep them clean and use them properly and very few of them but what will give years of service before wearing out. Do not be too ready to blame the manufacturer. Occasionally he is to blame but far oftener you have no one to blame except yourself when trouble does occur. As we have said before, the best way to shoot trouble is to shoot it before it becomes trouble.

CHAPTER XXVI

ADAPTING PHYSIOTHERAPY TO PRIVATE PRACTICE OR GENERAL HOSPITALS

These questions are going to arise with every therapist, no matter what particular specialty he may be following, "Can I afford to install physical appliances in my office? Have I the room? Can I learn to use them successfully if I do? Can I afford to have a technician to give the treatments for me as I prescribe them?" Every general hospital is soon going to have to answer the same questions.

The answer to the first question is the same for both. No one, individual physician, group or hospital pretending to do modern therapy can lay claim to be using the best methods of treatment if they ignore the most positive—and most efficient—group of remedies in the therapeutic field—the physical remedies. No therapist but who has constant use for any one of the physical remedies. How can any drug, any surgical procedure, *any other* remedy produce the reaction in living tissues produced—say—by properly applied conversive heat? The answer is that it cannot. Does any one with any knowledge of the reaction and its many times specific effects and its always beneficial effects (provided, of course, that it is indicated) presume to say that *he* can get along without it? If he attempts it some one else in his line who does use it correctly is going to make him change his diagnoses so often that he will soon get to be known as "the great reverser." This practice of changing a diagnosis after a "nothing can be done" prognosis had been given and the case later had cleared up after a course in the physiotherapy department became so common in one excellent hospital (equipped and manned almost ideally for precise diagnosis) that I was driven to arise in a staff meeting and request that, thereafter, the diagnoses sent to the physiotherapy department be changed or certified to *before* the treatment was started. The reaction was a hearty laugh and a cessation of the practice.

This most aggravating subterfuge at another time led me to remark, in the course of reading a paper in a section of the Academy of Medicine, that "it was indeed a very strange thing the number of perfectly good diagnoses that now were being changed in institutions where before the establishment of a well equipped physiotherapy service their diagnoses had been defended unto the death." I have heard a more than prominent nerve disease specialist remark in a crowd outside the door after a lecture during which the new treatment of locomotor ataxia was outlined that "if any one can *prove to me* that he can clear up an ataxia then I am ready to make an affidavit that the case was not one of tabes dorsalis." Judged by methods of treatment which he had used and the results he had obtained therefrom his statement was probably correct, but is this an attitude that will make for progress? Can it be said to be fair and unprejudiced? It assures the man who attempts to attack a problem from a new angle about as fair a trial as was given the suspect by a western judge who arose at the bench and addressed the prisoner. "We are going to allow you to have any lawyer you choose, make any plea you want, introduce all the evidence you have and in every way see that you get a fair and impartial trial but, when all these formalities are over, we are going to take you out and hang you higher than Haman's kite."

The same statement as to the indispensability of conversive heat to any therapist holds for ultraviolet and most of the other physical remedies. Therapy has to do with reactions and the thing that will produce the reaction most positively, most quickly, and most economically (that is, with least damage locally or generally) is, certainly, the *best therapy*. Outside the specifics there is nothing in therapy that will compare with the physical remedies upon these points. If a tissue is viable and reactive then you can produce your reaction and if the reactivity of a part or a patient is so low that no reaction follows their application then other remedies are fettered by the same handicap.

The question of room is often troublesome. In hospitals the older services usually are cramped for room and resent any talk of taking from their already cramped space enough room to establish a physical service. Lucky is the physiotherapist who

can plan his department in a new building. One thing should never be done. The new department should not be crowded into a damp basement or into cramped quarters in between other departments where future expansion is impossible, because, if the department is competently run, it will expand as sure as fate and as fast as blackmail. The work of the aides or masseurs is very hard (try an eight hour shift alongside a good worker and see if you can smile at the end) and they require fresh air and sunlight. Apparatus will work better, last longer and give much less trouble if the department is properly placed, and the personnel will do more work, better work and stay on the job without illness much more consistently in the same circumstances. The department should be located accessibly as many of the cases will be litter or wheelchair cases. The wiring and fusing of the department is an important thing. It is a mistake to try to run the various outfits from the house wiring as overheating of the wires from overload is liable to cause a fire, burn out fuses repeatedly, or cut down the performance of outfits from inability to draw enough current. A fifteen hundred watt lamp pulls about thirteen and a half amperes of current at 110 volts and this alone is too much for a small extension wire or the small wire often used in fixtures and, of course, for a ten ampere fuse with which many of these incandescent circuits are fused. We can easily figure the wattage load by adding up the wattage of the various outfits to be used on the circuit. Say we have a one kilowatt high frequency transformer outfit, a fifteen hundred watt deep therapy lamp, an 8 bulb baker fitted with eight 60 watt bulbs and an ultraviolet lamp to work from one circuit. (It is better to have the ultraviolet lamp on a separate circuit if possible to prevent voltage falls while in use). Then you have 1000 watts plus 1500 watts plus 480 watts (8 bulbs at 60 watts) and a lamp that will pull twelve to fifteen amperes at the moment of starting but which drops the amperage down to about three and a half in five or six minutes. Allowing for a maximum brief pull of this lamp for a few moments and assuming that at the time you light it the other outfits are going you have a possible wattage load of 1000+1500+480+1650 (15 amps. at 110 v.) which would be 4630 watts. Dividing the voltage into this to get the amperage you would have slightly over 42 amperes at 110 volts.

Thus, to be safe, fifty, or, better, sixty ampere fuses and a wire large enough to carry this amperage would have to be used. If two or three circuits are in the room pulling from different fuses then the load can be divided among the circuits according to their capacity. Our practice is to run in large wire (60 ampere capacity) in the conduit, tap off three or not more than four openings from this, fuse it to 60 amperes and have enough of these circuits to allow all the outfits to be in use at once if desired. I found that the ultraviolet lamps gave much increased efficiency if they were used on circuits from which no other outfits were pulling current. When I was allowed to design my own department I put the ultraviolet lamps, not only on a separate circuit, but ran those circuits to a special transformer on a post just outside the building from which no other circuit drew. This is desirable but not necessary unless you have large numbers of all kinds of outfits drawing current and a large number of ultraviolet lamps, but in any event the ultraviolet and x-ray outfits especially should be fed from a circuit having no voltage variation or the least possible variation. In a private office where only one outfit at a time is in use, the problem is not so difficult. The average doctor's office has enough old and practically useless furniture, storage cabinets, etc., in it that can be moved out with no real loss to efficiency to make room for quite a bit of apparatus. If room is an acute problem many of the outfits such as the deep therapy lamps, the ultraviolet lamps, etc., can be counterweighted and suspended from the walls or ceilings. It is amazing what a little ingenious planning will accomplish. A closet may be torn out here, a partition offset or moved a few inches there or one treatment table placed between two outfits and made to answer for both, etc. An adjacent room may be rented and the outfits installed in cubicles in it and removed from the main office. A group of physicians or specialists may fit up a common treatment room, etc. There is always a way to scheme out the room if you realize the necessity for having the installation made.

"Can I learn to use the outfits after I buy them?" It would be impugning a physician's intelligence to say that he could not. A medical man has every advantage over a nonmedical technician, and hundreds of these latter learned to do this work in our clinic

and hundreds more in other clinics. Some of them became very expert at the giving of these treatments. If a doctor is so busy in his work that he "has no time" to give these treatments himself then he is lucky. He certainly can afford to train an assistant to do it for him. The retort that patients will not pay enough for the treatments to justify them is a confession of poor salesmanship. The same patient that you think will not pay *you* for the work will go to an irregular and pay even higher rates cheerfully *and pay cash in advance.* Why? Salesmanship pure and simple. Every successful irregular is a good salesman. He *must* be because he has to make his sales under a much greater handicap than a medical man works under.

The question of technicians is going to come up. Shall I train a man or woman to give these treatments under my direction? I am going to give my experience just as it happened. Both men and women gave us good service but we found that the average man was inclined to become "chesty" as soon as he *thought* that he knew it all and a very large proportion of men jumped out as soon as they could and tried to pose as a doctor and do the work on their own initiative. Those that did not adopt this attitude made excellent assistants. Practically every one of the men who jumped out failed in a very short time and several tried to re-enter our service. Of all the aides (many more than two hundred) that were trained in our clinic we know of only *one* case where one of these girls tried to go it alone on the outside. Her rating with us was extremely poor, and she lasted only a few months before failing in her venture.

I have never known of anything approaching the devotion of these girls to their work. They worked hard all day, attended lectures on technic after hours, held quizzes during the noon hour and in the evenings and could be found in the clinic until late hours trying out technics one upon the other, etc. They were all volunteers and, almost without a single exception, women of superior education and personal qualities (a high school education was the minimum requirement). At one time when a canvass was made to settle a staff argument it was found that twenty-seven out of ninety of the physiotherapy aides on duty at that time had a degree from some of the larger women's colleges and five of these held two degrees. When, due to the sudden calling upon the

service to treat large numbers of a certain class of cases, waiting lists had to be posted these girls volunteered to stagger their duty hours and work through the noon hour and an extra hour after closing time and when this did not enable them to wipe out the waiting list they *insisted* that they be permitted to open up the clinic in the evening and do two hours of intensely hard work in addition to their full day's work. We had to prove to them by actual trial that no one could stand this sort of thing for any great time but meanwhile the service was expanding all the time so that they bridged the gap and paid for it with thirty per cent of them sick from overwork. We literally had to herd them out of the clinic and out of the hospital when the clinic closed. They would "loan" a radiant light and heat applicator to a ward and then slip in to the ward late at night to give massage if we did not watch them closely. We found the greatest difficulty in inducing some of them to accept promotion because such promotion to head aideship meant more paper work and less actual giving of treatments, and several, after we argued them into the proper frame of mind to accept the promotion, renounced the promotion and had themselves reduced a grade so that they could actually do the work themselves. No corps ever displayed greater loyalty, more unselfishness, greater devotion to duty or a better general high average of efficiency, from the chief aide to the humblest assistant aide, than did the reconstruction aide body during the heaviest work of the reconstruction period. Their *esprit de corps* became a thing remarked upon by all who observed their work. We feel that no written or verbal effort of ours will ever result in giving them more than a part of the credit due them. They were beyond mere praise.

Another question that is asked daily is as to which physical appliance is the most generally all around useful or to put it another way, "Which one would you install if you were to start on a small scale?" This question is incapable of a direct answer. So many things would enter into my decision that I would have to know all the factors such as the average class of cases I was to treat, etc., before I would choose. I can hardly imagine myself trying to get along with a single outfit, but I realize that this is the way most physicians will start out and therefore I shall try to put myself in the other man's place. Due to the wide range of

effectiveness of both conversive heat and ultraviolet ray I would linger long on the choice between them and, having made the choice, would not rest until I had acquired the other one too. I would probably choose a first class high frequency outfit (a poor one is too expensive at any price) for the nucleus of the installation, followed as soon as possible by ultraviolet, static, x-ray and later by the low-tension modalities. Other devices for applying the different forms of heat would be added as possible and the clinic gradually rounded out. It is not necessary to spend huge amounts of money to make these installations. Some of the most elaborate and expensive installations I have ever seen were not nearly so efficient or practical as one that I could have laid out for one-fifth the money expended. "Front" is the last thing to be considered. If a thing is not practical—cannot be made to pay handsomely its installation cost, its proper pro-rata of overhead, give efficient service, etc.—it is not for me. No business can afford to be loaded with nonproducers. One of the things that is hurting the game today is the practice that a few unprincipled agents have of loading a physician with a lot of more or less efficient (but always expensive) apparatus that he—from the nature and size of his practice—could not make pay for itself in two or three times the life of the apparatus. Many a physician today is up to his ears in debt trying to pay out some such installation that, were I in his place, I would hardly consider agreeing to pay the rent on the space it occupies for the use of it let alone assuming the cost of its installation and its upkeep. Such sharp practices hurt the honest men in the game and hurt the game. It is *not* good business. It is not my intention to say that no one should go into debt for *what he needs*. If a thing can be made to pay the interest and overhead and pay for itself before it is worn out, then it would be poor business to do without it. I am touching upon this only because I frequently have doctors in my classes that, after they see the relative importance of the various appliances, strongly desire to purchase the needed equipment but are compelled to *do without it for some years* while they pay out some less needed apparatus of a much more expensive character than they would have needed for the work it is called upon to do.

CHAPTER XXVII

A FEW GENERAL CONSIDERATIONS

The man who buys a high frequency machine (or any other single physical appliance) and sets himself up as a physiotherapist is foredoomed to failure. No matter how good the single appliance is or how skillful a technic he may acquire it is utterly incapable of producing the many different kinds of reactions that he *must* be able to produce to succeed. He is up against the identical thing that causes all systems of treatment using a single procedure, or it and its modifications, to fail. These "isms," "pathies," etc., may fool the public for a while by flaunting a few good results obtained by using the remedies upon *properly selected* cases but when they try to treat unsuitable conditions and especially dangerous contagious diseases, they fail and their failure endangers the individual or the whole body public. Take the high frequency outfit as an example. A competent medical man with a good high frequency outfit, knowing how and *when* to use it, can cover a wider range of the therapeutic field in a much more efficient manner than any single one of these short-cut-to-the-practice-of-medicine systems, yet no competent medical man would dream of using high frequency for *everything* that came into his office. If he did so use it, he would not be competent. There are some things it will do completely and alone; many others where it is an indispensable adjunct and its use will enable another procedure to succeed where the other procedure used alone would certainly fail; many other conditions where its use would do no good and others where its use would be followed by disaster. This holds for *any* other procedure or system.

The therapist is in much the same position as the conductor of a symphony orchestra. The latter must know the theory of music in *all* its subdivisions. He must know a proper tone when he hears it; must be able to recognize a potential discord when he sees it printed on paper or to detect it instantly when some performer in the orchestra misreads the print or inadvertently

strikes a wrong note, sharps or flats a tone, comes in a sixtieth of a second too soon or too late or spoils the ensemble by overemphasizing even a correct note played in perfect time and tune, etc., etc. He *must not* allow personal preferences for a certain instrument or certain kinds of instruments to cause him to "load" his orchestra with that kind of instruments to the detriment of the others or he will *never* be recognized as a good musician. He may be an unchallenged virtuoso in his playing of a violin and may believe, absolutely, that no other instrument can possibly compare with this instrument as a means of interpreting music and may be able to prove his point both theoretically and practically yet he must keep his personal preferences under control and recognize the indispensability of each of the other instruments and use them in their proper proportion or, if he insists upon forming an orchestra exclusively of violins, he must—unless he wants to make himself and his orchestra ridiculous—*confine his renditions to the very limited repertoire* of music composed for such a freak organization. He must be able to recognize a harmonious tone from a discordant one, no matter from what instrument produced; must be able to differentiate perfect technic from sloppy performance, discard such performers or train them up to efficiency; must be able to pick the instruments he wants to play at any given time to produce a certain quantitative and qualitative tonal effect and must *insist* upon his right to *compel* any man or men in the orchestra to deliver exactly what *he* wants in the way of sound at a given time and not what the *performer thinks* should be played else the ensemble will be one of discord instead of harmony. He may accede to the request of an "angel" or the public to have certain selections played at certain times (if he does not he will have to hunt a new "angel" to finance his organization) but such sensible cooperation with his backers does not carry with it the right of such backers or any members of the audience to step up and attempt to conduct the selection. If it did then the performance would instantly degenerate into a farce comedy, the conductors would refuse to be a party to any such horseplay and symphony orchestras would cease to exist because no qualified conductor would attempt to build up an efficient orchestra when he knew

that as soon as he had it trained up to efficiency some one was going to step up and wreck it.

This thing is a complete analogy to what is taking place in physiotherapy in many hospitals today and threatens the very existence of physiotherapy. Practically no progress or efficiency in the reconstruction section of the service hospitals in the early reconstruction period following the late war was possible until an order came out separating the physiotherapy service from the medical, surgical or other services and establishing it as a separate service on a par with the other services. My copy of this order is packed among thousands of other documents and case histories and I cannot lay my hands upon it without making a search that would require too much time, but I can give the exact sense of the order even though I may not quote it verbatim.

It read almost exactly as follows:

From: The Surgeon General U. S. Army.
To: Commanding Officers All Base and General Hospitals.
Subject: Status of Physiotherapy Department.

1. The physiotherapy department is not a part of the surgical service or a part of the medical service or of any other service but is placed in the hospital for the use of all services on the same basis, etc.
2. The enlisted personnel comprising the physiotherapy department *rate as specialists* [italics mine] and as such cannot be compelled to take part in ceremonies, guard, police or other routine duties except in the direst emergencies.
3. Etc., etc.

This order stopped several things that were making for chaos in the physiotherapy departments. Such minor aggravations as having a man who had had years of training, say in hydrotherapy work (one of our operatives spent two years in Nauheim studying the technic used there), placed upon the kitchen police for a week at a time and set to peeling potatoes or some other equally technical work or put to picking up cigarette butts on the outside police while, due to the impossibility of detailing another man to do his work, the hydrotherapy department had to be shut down, were made impossible. Protests to the personnel officer (if he was hard-

boiled, and that place usually requires a man who cannot see excuses) only resulted in his seeing to it that the physiotherapy enlisted personnel did not slack their "duties." Of course such a state of affairs could not long be tolerated and was remedied by the order in question. I am not blaming the personnel officer. He had to maintain morale and see that all the work on the post was done and if he released several men in one department from their duties he had to recognize other departments too and if he did his working force was shot full of holes so that he usually "seen his duty and done it."

By far the most serious check to efficiency in the department, however, came when the department was placed under the surgical or medical service. No chief of service, section or ward surgeon would have presumed to have referred a case to the eye, ear, nose and throat department for an eye operation with detailed instructions as to exactly what anesthetic was to be given, what incision was to be made, what instruments were to be used, what antiseptic applied, what suture material and stitch used to close up the incision and what dressing applied with instructions as to how often the dressing was to be changed, etc., etc. If he had, his instructions would have been the source of much merriment and would, very properly, have been disregarded. Why? Because the eye man is recognized as a specialist and, as such, is *conceded* to know more about his line and to have better technic for doing his work than other medical men not specializing in that line.

If we could have used the hot water that we were constantly getting ourselves into as a result of our consistently refusing to administer the wrong treatments with an absurd technic that were being prescribed by a hundred and forty-seven different doctors with a hundred and forty-seven radically different ideas as to the proper technic to be used in our department and who positively stood upon their rights to have such treatment administered *just as they prescribed it,* we would have needed no storage tank, water heaters, or anything else except oversize drain pipes. We finally, in desperation (this was before the order came out) put it squarely up to our Colonel Commanding to courtmartial us, discharge us, or give us a decent working chance, and after carefully considering the matter and admitting that it was improbable that any one having to use at least a hundred and forty-six wrong technics

would do good work he decided to back us up and did so with the warning that it would be considerably to our personal profit to make good on our contentions. This was all that we were contending for and all that any one is entitled to—a *fair* trial. He issued an order that cases would be referred to the department for treatment with a statement as to what was wanted done but stated that the manner of doing it would be left entirely up to the physiotherapist who would be held rigidly accountable for results. That

Fig. 83.—A table in the wicker work section of the occupational therapy department.

day marked the beginning of real efficiency in the physiotherapy work and a few months later no one of all the boosters on the staff could say as much for physiotherapy as the commanding officer himself. A short time later this general order came out definitely establishing the physiotherapist as a *specialist* and from that time on physiotherapy progressed like a fire in thick, dry grass.

It was a sad blow at efficiency when, in July, 1920, an army order came through abolishing the physiotherapy service as a

separate department and placing it under the orthopedic section of the surgical service. The Surgeon General could find no other way to save the service from extinction as it was the newest service established and when the appropriations for the medical service of the army were cut to a point that did not enable them to function fully even along the old established lines the newer expansions had to be curtailed along with the older ones or be cut off completely. The merger order was the inevitable sequel. The result was easily foretold by any one who had been through the maddening struggles that we had to place physiotherapy out of the reach of the prejudices and jealousies of other sections and I immediately renounced my intention of accepting a commission

Fig. 84.—Corner of occupational therapy department.

in the reorganized medical corps under any such conditions. I announced my intention of offering my resignation effective upon the date of the order making the change and was persuaded to withhold it upon the assurance that the policy would not be inaugurated at our hospital as it was to be closed in a few months anyway, so that the change was never made in our hospital.

When the United States Public Health Service took over this and other hospitals and assumed the reconstruction work they were given certain funds which made the establishment of a reconstruction section (composed of the physiotherapy and occupational therapy departments) possible and they adopted an even better system than the original army system. They placed a single medical officer—the reconstruction officer—in charge of both depart-

ments. In the army the occupational therapy department was under nonmedical officers. Occasionally one of these chiefs resented a suggestion that possibly three or four hours continuous work at a jig saw was too much for a convalescent nerve injury leg paralysis, etc. And it was not unknown for one of these nonmedical chiefs to give out a long list of patients that had been "cured" by occupational therapy with no hint or mention of the many weary months' work put in upon a large proportion of these same cases by the physiotherapy service before they were even able to take up occupational therapy at all or without which occupational therapy alone would have failed. In addition to this the *nonmedical chiefs* of these *therapy* departments were not bound

Fig. 85.—Corner in occupational therapy department.

by any code of ethics forbidding advertising. They taught—among other things—advertising and had many expert advertisers on their staff. They believed in advertising and demonstrated their belief by using it to the limit. The local hospital papers were made up and printed in their department and it was a very lucky physiotherapist who could "make" their columns with any except the most inconsequential piffle. They taught many things that required outside help and publicity and the social service workers and others interested in reconstruction work were given special opportunities to see the wheels go round and see the wounded in the last stages of their treatment (vocational training) and so the inevitable result was that this section "made" the Sunday supplements almost weekly; was so well broadcasted that

every one knew of it and the work it was doing, gave it their moral and financial support and gradually built up a feeling in non-medical officialdom that it was nearly the whole thing in reconstruction. This attitude was reflected in the appropriations and even back into the hospitals themselves.

I well remember the profane but expressive comment of a distinguished senator who was visiting our hospital. He had a relative being treated in the physiotherapy department and came in to watch his treatment. He was thoroughly familiar with every phase of occupational therapy and, as he expressed it, was willing to give them anything they asked for at any time, but had never *heard* of physiotherapy. He was astounded at the size of the physiotherapy department, the volume of treatments being given, the classes of cases treated and, more than all else, the results that were being obtained. (He checked the results by talking with many of the patients and visiting the ward surgeons and the other services.) His first question when he returned was, "Why, in the name of common sense, do you not advertise this work as the others are doing? How can you expect support when we do not know that you exist? Stop your foolish policy of hiding your work and refusing publicity. Get onto the front page even if you have to scrap to do it, etc." It may be a coincidence that the next week after his visit a feature reporter for one of the largest news syndicates walked into our office accompanied by two expert camera men and *insisted* upon their right to photograph everything in the place and run feature articles. We had troubles of our own and had no desire to monkey with the T. N. T. of feature publicity and it took one whole day to bribe them off. This we did by promising to call them up and give them an exclusive feature story on our x-ray-ultraviolet ray researches *as soon as they were finished.* I have their telephone number in my note book and hope to be able to call them some day *when* this work is finished. One of my hardest tasks was to keep the good work being done from being blasted by ill-advised sensational publicity.

No such surging is possible when both branches of therapy in the section are under one head (medical as it *always* should be) who realizes that a team that is constantly surging one against the other does not make progress in moving a heavy load but that the energy thus expended, if put into steady pulling, will move any-

thing movable. I do not wish to give the impression that I decry occupational therapy. I realize its tremendous value as much as any one. What I am pointing out is the mistake of placing a whole *therapeutic department* under nonmedical chiefs. It is all right to have the various sections in the department under trained nonmedical men (this, in some of the larger and more technical sections, is desirable) provided they in turn are under some kind of medical supervision and are not allowed to override medical opinion as to the proper form and amount of therapy for a given case.

In the *highly specialized* work of physiotherapy it is fatal to success to place a physiotherapist or his department in a position where he is *compelled* to administer treatments that he knows to be absurd or is forbidden to treat cases he knows are particularly suited for physiotherapy until after the case has run the gamut of *all* other services and has reached such a stage that it is, by common consent, moved into "St. Peter's ward" for final "observations." Physiotherapy has one thing in common with all other therapeutic procedures: when it is indicated its efficiency is very greatly enhanced by its early use. Prejudice and jealousy should not be allowed to forbid its use or compel its wrong use. These things happen, inevitably, when it is placed under one of the old services. These men, admittedly knowing nothing of any of the branches of physiotherapy except massage and hydro and positively sure that these two branches "comprise 90 per cent of physiotherapy" (their knowledge of even these two branches is mostly hearsay) compel the use of these branches and forbid the use of other and much more valuable branches and such a "Physiotherapy" department rapidly slides down the scale until it is a mere massage emporium of *very restricted efficiency*. If their object is to kill the effectiveness of the department they should be proud of their work—it does it beautifully. Until human nature changes or the older specialties can be made to see the truth that physiotherapy, by extending their field limits, more than makes up to them the loss that they suffer in the conditions they formerly treated but where physiotherapy alone now fills the bill, they are going to fight stubbornly to hold their ground. A realization of this fact is slowly becoming evident and the full recognition of it spells grief to the irregulars.

Every surgeon, internist and specialist is such for one purpose alone. All other things such as the laborious, highly difficult, complicated—and often expensive—technical procedures sometimes necessary to establish a correct diagnosis must be subordinated to that one thing. Indispensable as a correct diagnosis is, it is (from the patient's standpoint) *useless* if at the end of months of observation, submission to multiple diagnostic procedures, etc., he is told that nothing can be done for him. And often, *much too often,* this is what happens. Therapy then, is the one thing—the nucleus—around which all branches of medicine revolve. No branch of medicine is subject to such slow changes as that of therapy. A statement is made in a standard text book that a certain condition is incurable or that nothing can be done for it. This statement is repeated through succeeding editions, copied into other text books and perpetuated. It is a work of years and years to cast the slightest doubt upon the infallibility of this statement—true enough perhaps when *first* made—and the one attempting to do so will be made to wish, many times, that he had died ere he had the temerity to attack so sacrosanct a statement. Such statements should not be made in the first place without some such qualification as "The condition is incurable by any *present methods* of treatment." The more famous the man making the statement, the more unfair it is to future therapists for him to leave it unqualified.

I well remember the statement made to me by several prominent roentgenotherapists when I was attempting (unsuccessfully) to get them to *try* a method of clearing up an acute x-ray burn that had proved uniformly successful in my hands. Their invariable retort was, "But, do you not know that it is *against all the rules of the game* to superimpose *any* other kind of a dermatitis upon a beginning or an acute x-ray dermatitis?" I knew this but when a game has been played unsuccessfully for more than twenty years there is just a chance that some of the rules of the game might have an exception so I investigated, very cautiously at first, and found that in this instance there were exceptions. Even when I was ready to publish my preliminary research upon the prevention of x-ray burn (which is the real title of the Leonard Research Thesis) I did not dare to give the full truth for fear that some one trying to duplicate my dosages might not have as good an ultra-

violet lamp as I had or might be too timid in the use of it and so damage some patient severely with the x-ray and discredit the method. I gave figures only slightly in excess of maximum dosages in use and stated that these were not the limits but that "Whether these dosages can be much extended is a problem for future research" thus putting responsibility for exceeding them up to the one so doing. Even with all my care I have been quoted as having said that "once a skin has been tanned with the actinic ray *any dosage* [italics mine] of x-ray can be given through the tanned area without producing a burn," as if the tanning were the only factor when I emphasized the fact that it was only one factor and a very small factor at that. I feel sorry for any one trying to prove that misstatement with any serious overdose of x-ray. I could multiply misquotations at length, some of them (as the one given) serious, some embarrassing and some ludicrous. A single example of the latter will suffice. A very sedate physician in his late fifties was attending a lecture wherein I made the point that the full capacity of a large static machine would not kill a mouse. Several ladies were in the audience (reconstruction aides, nurses, sisters from local hospitals) and for fear that some of them might belong to the local branch of the Society for the Prevention of Cruelty to Animals I stated that we had found a *mouse suffering with arthritis* and had proceeded to treat his joints for twelve days with the full capacity of the largest static made and at the end of three weeks observation following his treatments he was the most lively mouse in the whole bunch of controls, etc. This physician, in talking over the lecture the next day informed another professional friend of mine who had not been able to attend the lecture that I had given out a treatment for "joint mice" and this friend came to the hotel to find out just what the new treatment was.

No irregular group is equipped and manned with the elaborate scientific modern facilities and highly trained personnel with a knowledge of *all* the factors entering into the correct use of these facilities such as is possessed by every medical center for that first requisite for every successful attack—locating and accurately estimating the enemy—a diagnosis. If an army of superior size, equipped with vastly more and better artillery and having the use of an infinitely larger, better trained and equipped aerial observer

force cannot win the battle it will be because they lack morale, marksmanship or because their shells are mostly "duds." If some one points out and proves to them that their ammunition is deficient in explosive qualities and they yet insist upon using the old ammunition because it was good enough for their ancestors they are due for a very costly lesson that a little more open-minded attitude would have averted. Real guns loaded with such ammunition are little better than Quaker guns. The permitting of the enemy to glimpse a vast array of Quaker guns to *deter* attack may be good strategy but when the attack is *on* and is being rammed home it is about time to discard them. If the S. O. S. section (service of supplies) fails to function efficiently in such a crisis, both as to quantity and quality of ammunition furnished them, it is up to those bearing the brunt of the attack to *send out the S. O. S.* for a Lloyd George to see that they do get proper shells in q. s. If, after such shells are delivered they refuse to use them they will deserve all that will come to them and, both ways, in the language of the street, "This will be plenty."

I do not believe that the practice of giving long series of complete case reports, detailing the treatment, when such treatment is nonmedical, serves the best interest. I spent some ten months writing this book originally and have spent some additional eighteen months unwriting it. I wish that I might have said even less than I have had to say to make my meaning clear. I tried for more than a year to have the book sold only upon subscription, but I have become convinced that that would not result in any good whatever. If I cannot control the distribution of a book I can control attendance at lectures and that is what I have done. This subject ought to be and very soon will be taught *thoroughly* in every medical school. The field for the proper administration of these physical remedies is so large that I never expect to live to see the limits reached. Even now I have, for trial, two brand new appliances—one for the administration of the ultrared rays alone and the other for the joint administration of the ultrared and the ultraviolet. (Why should we say "ultra" violet and "infra" red? If "infra" is correct in the one case then "supra" is the proper term in the other. It would seem preferable to use the prefix "ultra" in both cases.) The "black body" ultrared appliances so kindly sent me for advance trial by Mr. F. F. Bur-

dick I have had no opportunity to try out. It is not hard to calculate where their field will be in therapy. Any condition that will be cleared up or benefited by the formation of a mild hyperemia will respond to any agency such as these or some of the magnetic wave generators which produce such mild hyperemia.

The arc lamp for the joint application of ultraviolet and ultrared is of a radically different construction from any previous arc. The arc burning in a closed (and almost a vacuum) chamber causes combustion of the gases (notably cyanogen) which are formed as a result of the much higher temperature of the arc itself than is present in an open arc and which gases give the emitted rays an intensity in certain ultraviolet and ultrared regions not possessed by the open arc. The arc flame itself is much longer than that of an open arc, being fifty millimeters long (2 inches) on the lamp I have. Two chimneys are furnished, one of which is of uviol glass and cuts off the ultraviolet rays shorter than 2900 A°. The other is of quartz and passes out all the ultraviolet formed which goes to about 2200 A°. A peculiar feature of the lamp is the very much reduced *local* reactions that ensue from its use. The addition of quantities of ultrared to the ultraviolet seems to overcome the irritant skin effect of the latter to a large degree. After trying the lamp cautiously upon small areas I spent twenty-eight minutes under it at a burner-skin distance of 16 inches with the whole back exposed with only a slight reaction—hardly more than a first degree. Various chemical tests prove the presence of such quantities of ultraviolet that without some such combination of wave lengths as is given off by this arc heavy skin reactions would surely follow such lengthy applications. Five months trial is too short a time upon which to base conclusions, but if I were to state a conclusion it would be that the new arc will fit in nicely where the constitutional effects of ultraviolet are wanted and local effects are not desired. It may well be that the new combination will give new results in local effects, but as yet I have had no opportunity to try it out for these as I am not at present connected with a clinic where such trials could be made. Prof. Emil Hoffman—through whose kindness I have been allowed an advance trial of the arc—has also brought over from Germany an actinimeter which, so far as I can see without dissecting it, works along the same principle as an x-ray iontoquantimeter and which may permit

of the working out of a standardized ultraviolet technic when its action is thoroughly understood. This will all take time.

I had also intended including a chapter upon a most wonderful cutting instrument (not a cold cautery) for the use of surgeons—the Electro-Scalpel—but the maker has had it in use in the Mayo Clinic for some months and I do not wish to anticipate their report. Suffice it to say that it differs so radically from anything else that there is nothing with which to compare it and has many advantages not the least of which is the very low voltage used. (Not enough to puncture a *dry* sheet of newspaper.)

Other new things are incubating so fast as to make me, at times, seriously consider leaving the poorly paid field of educational work and enter the more remunerative developmental end of the game but when the time comes to cut loose from my chosen task and I sharpen up my knife with the full intention of so doing, the urge to make my goal before turning aside to financial rewards strikes me with renewed force and I hit the road again. It has been said that fools learn only from experience, but that is all wrong. A fool does not learn from experience—his or others. The man who learns from his experience is no fool and the man who learns from the experience of others is, indeed, the opposite of foolish. I have an ideal and until it is realized or totally destroyed I shall not stop. I hope to live to see the book of therapy rewritten and modernized and believe that I shall. Negative therapy has had its day—and a *long day* too—and the negative therapy charged public cannot be attracted by a negative therapy charged profession. The sooner we change our reaction the better for us.

If my efforts in the clinic, on the lecture platform or in this book towards explaining, simplifying and making more efficient the application of those most positive of all remedies—the physical agencies—result in the helping of the many other earnest workers in this field to popularize and secure a trial of these remedies *under fair conditions,* then I shall consider myself *richly* paid for in such circumstances it means their adoption. Their adoption means a change to positive therapy on the part of the profession and a change to positive dismay on the part of the short-cut-therapy cults. *Ne plus ultra.*

CHAPTER XXVIII

DEFINITIONS

As constant reference will be made in the text to certain terms, it is essential that we have an understanding of these terms. My definition may or may not coincide with the one already learned by the reader from some other text book in which case it is used as defined here.

The definitions are not given in alphabetical order, but are arranged according to association of words, or in their logical sequence.

Physiotherapy: Positive therapy. Applied physics. The use of physical remedies in the treatment of disease or disability.

Electron: An extremely minute corpuscle or charge of negative electricity, the smallest that can exist.

Proton: The nuclear positive corpuscle of electricity.

Atom: A central or nuclear group of protons and electrons surrounded by numbers of electrons. The number of positive and negative charges varies with the character of the atom but is always the same for an atom of a given substance. The electrons not included in the nuclear group are called planetary electrons. If the sum total of all the positive and negative charges just balance, then it is a normal atom but if not then it is called an ion.

Molecule: Two or more atoms in combination. If the charges exactly balance, then it is a normal molecule, but if an excess or deficiency of either charge is present then it is not called a molecule but an ion.

Ion: An ion is an unbalanced charge atom or molecule. The word means to go or to travel. As long as the atomic or molecular system remains unbalanced (or an ion) it does not exhibit its ordinary chemical combining properties, but when the charge is normalized or balanced again it again acquires all of its chemical combining properties. When a polarity current is passed through an electrolyte or human tissue the ions travel both ways. The ions having an excess of negative charge are repelled from the negative pole and attracted towards the positive and are thus called "anions" or ions that travel towards the anode. Those possessing the opposite charge and travelling towards the cathode are named "cations." The rate of travel of any ion is ex-

tremely slow unless very high voltages are impressed upon it. The hydrogen ion travels over twice as fast as the next fastest ion—the hydroxyl ion—so that under high voltages the hydrogen ion concentration is the most notable thing that occurs.

Ionization: The disruption of a solute when placed in solution (or gases under certain conditions) into ions or into ions and electrons. This disruption is automatic and independent of the application of any outside force. Solutions that ionize are conductors of electricity and those that do not are nonconductors. Acids, bases and salts are the best known examples of the former and chloroform, ether, alcohol, fats and certain oils of the latter.

Ionizing dose of x-ray: A substimulating dose of x-ray. Unless otherwise specified the term as used in the text refers to a dosage of 5 milliampere minutes with the following factors: 5 inch back up spark, one millimeter aluminum filter, 8 inch target-skin distance.

Milliampere minute: One milliampere for one minute.

Electrolyte: A solution which is a conductor of electricity.

Nonelectrolyte: A solution which is a nonconductor.

Acids: Electrolytes one of the dissociation products for which is always a hydrogen ion.

Bases: Electrolytes one of the dissociation products for which is always a hydroxyl ion (OH).

Salts: Electrolytes which are neither acids nor bases.

Anode: Positive pole.

Cathode: Negative pole.

Anions: Ions having an excess of negative charge and traveling towards the positive pole.

Cations: Ions having an excess of positive charge and traveling towards the negative pole.

Electrolysis: The breaking up of a compound substance by the action of electricity.

Volt: An electrical unit of pressure.

Ampere: An electrical unit of volume of flow.

Watt: An electrical unit of quantity of flow or rate at which energy is used.

Wattage: Voltage × Amperage = Wattage. Thus:—One ampere at 10 volts =10 watts, etc.

Monopolar: Use of one pole only in the giving of treatments.

Bipolar: Use of two poles in giving treatments.

Multipolar: Use of several electrodes from one or both cords.

Modality: Any mode or method of using a physical remedy in therapy. Massage, mechanical vibration, galvanic, static, nonvacuum high frequency, diathermia, whirlpool bath, or any single application would be called a modality.

High Frequency: A current having a frequency of interruption or change of direction sufficiently high that tetanic contractions are not set up when it is passed through living contractile tissues.

Low Frequency:	A current whose frequency is such that its passage in any quantity is attended by tetanic contraction. (These currents will be described in detail under proper headings.)
Meter:	A standardized device for measuring.
Ammeter:	A standardized device for measuring amperes.
Milliammeter or milliamperemeter	A standardized device for measuring milliamperes.
Milliampere	1/1000 of an ampere.
Hot wire meter:	A meter to measure high frequency currents. The needle of the meter is connected to a wire having a known expansion under the passage of a given milliamperage and as the wire expands under the passage of a given quantity of current the needle moves up on a calibrated dial until it indicates that amount. (It is really pulled up by a fine spring taking in the slack and as the wire cools it pulls the needle back against the spring until, when it is again cool, the needle rests on zero.)
Watt meter:	A meter for measuring quantity of flow.
Angström unit (A°):	A unit of wave length measurement used in measuring light wave lengths. It is 1/10,000,000 of a millimeter in length.
Millimicron ($\mu\mu$):	A unit of wave length measurement. It is one billionth of a meter in length or one-millionth of a millimeter, thus is ten times as long as an Angström unit. (The actual length of a wave is obtained by dividing the number of oscillations per second into the speed of light.)
Mains or main line:	The current as it comes in from the street supply or from the motor generator, if one is used.
Main switch:	The switch that, when closed, allows the current from the street mains or source of supply to enter the outfit.
Closed circuit:	A circuit through which current is passing or would pass.
Open circuit:	A circuit having some break in it so that current is not passing and cannot pass. This break may be intentional as an open switch, or accidental, as a blown fuse, loose connection, broken wire or other reasons.
In series:	A device is in series in the circuit when all current reaching the patient *must* go through it.
In shunt:	A device is in shunt when the current has choice of an *alternative* path; either through it or around through the patient or some other circuit depending upon which has the least resistance.
Rheostat:	A fixed or variable resistance for controlling amount of current entering a circuit.
Series Rheostat:	See "In series" above.
Shunt Rheostat:	See "In shunt" above.
Series or Shunt meter:	See same.

Ohm:	An electrical unit of resistance. It is the equivalent of the resistance offered to the passage of one ampere at one volt by a piece of copper wire 1/20″ in diameter and 200 feet long.
Conductor:	That which offers a comparatively low resistance to the passage of current through it.
Nonconductor:	That which offers such a high resistance that ordinary voltage currents will not traverse it.
Solenoid:	A coil or series of turns of wire spaced equally between turns.
Tension:	Sometimes used as a synonym for voltage. Thus: high tension would mean high voltage.
Potential:	Often used as a synonym for voltage.
Rheophore:	Old name of cord connecting patient to electrical outfit.
Rheotome Interrupter:	A clockwork device used on low voltage currents to interrupt passage of the current at a regular interval. On most outfits the so-called ''Rheotome interrupter'' is a misnomer as the current is not interrupted at all—cannot be because it is not passing—but the device really acts as an instantaneous make and break mechanism, the current only passing to the patient at the instant the rotating and projecting cam passes a fixed contact point.
Pole changing switch:	A switch by the reversing of which from one side to the other the polarity on a given cord is reversed.
Series lamp:	An incandescent lamp in series on the line entering a wall plate, cabinet or other appliance which cuts the amount of current that can possibly enter the appliance to just the amount that the lamp pulls, from less than a half ampere to about one ampere for the larger sized incandescent bulbs.
Kilowatt:	One thousand watts.
Inductance:	That property possessed by alternating and rapidly interrupted direct current circuits which enables them when placed near to, but insulated from, another solenoid, to induce a current in the second solenoid. This induction property is what makes transformers possible.
Transformer:	An electrical device for raising or lowering the voltage of an induction current.
Primary Transformer:	The first transformer which the 110 volt or 220 volt current from the street enters for the purpose of having the voltage raised. It consists of a primary solenoid and secondary solenoid placed in inductive relation to each other. They are usually wound upon, but insulated from, two opposite sides of an oblong, laminated iron core. This type is called a closed core type. Sometimes the two solenoids are superimposed one over the other on a straight iron core, each insulated from the core and each other, in which case it would be called an open core transformer. For efficiency reasons, nearly all transformers are of closed core type. The extent to

which the voltage is raised depends upon the mathematical ratio of the number of turns in the secondary to those in the primary. The greater the ratio of turns in secondary to those in primary the greater the voltage in the induced current coming from the secondary. For further information, I recommend a study of the physics of induction currents in any good elementary work on commercial electricity.

Condenser: See section on high frequency currents.

Spark Gap: See section on high frequency currents.

Leyden Jar: A glass jar coated partially, inside and out, with tin foil or coated outside with tin foil and having salt solution inside. Used as a condenser.

Spark ball or point electrode: An insulating handle having on one end a metallic ball or point. Used in giving static or high frequency sparks.

De Kraft Blue Pencil Electrode: A long, pencil-shaped electrode used in giving static effluve treatments. Designed by Dr. Fred DeKraft of New York City. Consists of a fiber or rubber shell filled with a composition of asbestos, etc., and having a ring on the blunt end for attaching the cord from the machine and a pointed metal tip on the end which is directed to the part under treatment.

Spark director: An insulating handle having a metallic tip so shaped that it projects at an angle and can be placed on the skin—say between the fingers, etc., and a spark delivered to it from a distance to any part of the body. The metal carrying the spark to the exact spot where it is desired and preventing it from jumping to some point that, but for the spark director, would be nearer the spark electrode and thus draw the spark.

Chain or cord holder: An insulating handle having a hook or ring in the end. Used for purpose of holding static connections away from patient or operator.

Hook-up: Used in speaking of the method of arranging circuits, appliances and electrodes in the giving of any particular treatment—as, for instance, the hook-up for direct sparks, etc.

Trouble shooting: Locating open circuits or other reasons for nonperformance or wrong performance in an electrical appliance.

Fuse: A safety device in series in a line, so made that when a volume of current larger than would be safe for the outfit or patient to receive attempts to go over the circuit the fuse will melt and so cut off the current.

Rectifier: A device for changing alternating current to direct current. Chemical or m[illegible]nical rectifiers are seldom used nowadays as a [illegible] generator set is much more efficient. A rotary converter set is also used to convert D. C. to A. C. for high frequency machines.

Choke coil: An electrical device using the inductive properties of alternating current for limiting current entering appliances. An automatic magnetic rheostat.

Auto transformer: An electrical device limiting the voltage entering an appliance, but not the amperage. For instance, a certain button on the auto transformer switch might make it impossible to get more than 30 volts into the outfit, but in case of a short circuit somewhere in the secondary line or an accidental short to the patient, an enormous amperage could pass. For this reason it is more efficient when used on heavy duty such as deep therapy x-ray outfits than a rheostat but in case of a short to the patient is very much more dangerous. In an outfit having only auto transformer control extreme care should be used to prevent such short occurring and the switch should never be left for a moment during the treatment of a patient.

INDEX

O

P

T

U